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# Bibliography of Lewis Research Center Technical Publications Announced in 1979

(NASA-TM-81525) BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1979 (NASA) 376 PHC A17/MF A01

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May 1980





#### PREFACE

In 1979, Lewis' 1050 research authors published 448 technical publications which were announced to and reached the worldwide scientific community. This number was our typical output even though we had a slight decrease in staff. In recent years, the trend in Lewis publishing has been that each year the number of technical presentations given at seminars, society symposia, and Lewis-hosted conferences has surpassed the record set the previous year. Lewis authors publish almost 60 percent of their research contributions in outside publications and the rest as NASA research reports. Lewis authors primarily use society proceedings, seminar presentations, and journal and transactions articles to describe their work.

In 1979, the production of 294 contractor-authored research reports was higher than the previous year's output of 267. In addition, 51 patent applications were filed, and 32 patents were issued, typical numbers for Lewis patent contributions.

In 1979, the annual award for Best Lewis Publication was presented to Walton L. Howes for his paper "Loudness of Steady Sounds - A New Theory," which delves deeply into the physical and physiological basis of sound perception. This journal article appeared in Acustica, volume 41, 1979, and is described in abstract A79-39375 (p. 176) in this bibliography. An expanded version of the journal article, entitled "Overall Loudness of Steady Sounds According to Theory and Experiment," was published as NASA RP-1001; it is described in abstract N79-25753 (p. 163) in this bibliography.

And in 1979, the Joint Propulsion Conference, sponsored by the American Institute of Aeronautics and Astronautics, the Society of Automotive Engineers, and the American Society of Mechanical Engineers, presented its award for Best Paper of the Year to James J. Pelouch, Jr., for his study "Low-Thrust Chemical Orbit Transfer Propulsion." This paper describes a unique Lewis capability to take the lead in generating the knowledge for low-thrust chemical propulsion. This presentation, AIAA Paper 79-1182, is described in abstract A79-39815 (p. 55) in this bibliography.

All the publications in this collection were announced in the 1979 issues of STAR (Scientific and Technical Aerospace Reports) and/or IAA (International Aerospace Abstracts).

The arrangement of the material is by NASA subject category, as noted in the Contents. The Lewis-authored items are listed first, followed by the contractor items. Within each of these groups is listed report literature, in N-number sequence, followed by the journal and conference presentations, in A-number sequence.

The various indexes will help locate specific publications by subject, author, contractor organization, contract number, and report number.

George Mandel Chief, Management Services Division

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### **01** AERONAUTICS (GENERAL)

N79-16796° National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
GENERATION OF LINEAR DYNAMIC MODELS FROM A
DIGITAL NONLINEAR SIMULATION
Carl J. Daniele and Susan M. Krosel Feb. 1979 95 p refs
(NASA-TP-1388; E-9490) Avail: NTIS HC A05/MF A01 CSCL
02A

The results and methodology used to derive linear models from a nonlinear simulation are presented. It is shown that averaged positive and negative perturbations in the state variables can reduce numerical errors in finite difference, partial derivative approximations and, in the control inputs, can better approximate the system response in both directions about the operating point. Both explicit and implicit formulations are addressed. Linear models are derived for the F 100 engine, and comparisons of transients are made with the nonlinear simulation. The problem of startup transients in the nonlinear simulation in making these comparisons is addressed. Also, reduction of the linear models is investigated using the modal and normal techniques. Reduced-order models of the F 100 are derived and compared with the full-state models.

N78-20008\* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
MATERIALS AND STRUCTURAL ASPECTS OF ADVANCED
GAS-TURBINE HELICOPTER ENGINES

John C. Freche (US Army Aviation Res. and Develop. Command, Cleveland) and John Acurio 1979 65 p refs To be presented at the Intern. Congr. in Aeron., Paris, 6-8 Jun. 1979 (NASA-TM-79100; AVRADCOM-TR-79-4) Avail: NTIS HC A04/MF A01 CSCL 21E

The key to improved helicopter gas turbine engine performance lies in the development of advanced materials and advanced structural and design concepts. The modification of the low temperature components of helicopter engines (such as the inlet particle separator), the introduction of composites for use in the engine front frame, the development of advanced materials with increased use-temperature capability for the engine hot section, can result in improved performance and/or decreased engine maintenance cost. A major emphasis in helicopte: engine design is the ability to design to meet a required lifetime. This, in turn, requires that the interrelated aspects of higher operating temperatures and pressures, cooling concepts, and environmental protection schemes be integrated into component design. The major material advances, coatings, and design life-prediction techniques pertinent to helicopter engines are reviewed; the current state-of-the-art is identified; and when appropriate, progress, problems, and future directions are assessed.

## **02** AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

For related information see also 34 Fluid Mechanics and Heat Transfer.

N78-10022\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AERODYNAMIC PERFORMANCE OF A 1.36-PRESSURE-RATIO AXIAL-FLOW FAN STAGE

Walter M. Osborn, Royce D. Moore, and Ronald J. Steinke Oct. 1978 108 p refs

(NASA-TP-1259; E-9025) Avail: NTIS HC A06/MF A01 CSCL 01A

The overall blade element performances and the aerodynamic design parameters are presented for a 1.35-pressure-ratio fan stage. The fan stage was designed for a weight flow of 32.7 kilograms per second and a tip speed of 302.8 meters per second. At design speed the stage peak efficiency of 0.879 occurred at a pressure ratio of 1.329 and design flow. Stage stall margin was approximately 14 percent. At design flow rotor officiency was 0.94 and the pressure ratio was 1.360.

N79-10023°# National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

A COMPUTER PROGRAM FOR THE CALCULATION OF THE FLOW FIELD IN SUPERSONIC MIXED-COMPRESSION INLETS AT ANGLE OF ATTACK USING THE THREE-DIMENSIONAL METHOD OF CHARACTERISTICS WITH DISCRETE SHOCK WAVE FITTING

Joseph Vedyak (Purdue Univ., West Lafayette, Inc.), Joe D. Hoffman (Purdue Univ., West Lafayette, Ind.), and Alian R Bishop Jun. 1978 173 p refs

(Grant NGR-15-005-191)

(NASA-TM-78947; E-9694) Avail: NTIS HC A08/MF A01

CSCL 01A

The calculation procedure is based on the method of characteristics for steady three-dimensional flow. The bow shock wave and the internal shock wave system were computed using a discrete shock wave fitting procedure. The general structure of the computer program is discussed, and a brief description of each subroutine is given. All program input parameters are defined, and a brief discussion on interpretation of the output is provided. A number of sample cases, complete with data deck listings, are presented. GG

N79-11000° # National Aeronautics and Space Administration. Lewis Research Center Cleveland Ohio. SUPERSONIC UNSTALLED FLUTTER

J. J. Adamczyk, M. E. Goldstein, and M. J. Hartmann 1978 24 p refs Presented at the 52d Meeting of the Propulsion and Energetics Panel, Cleveland, 23-27 Oct. 1978; sponsored by AGARD

(NASA-TM-79001: E-9785) Avail NTIS HC A02/MF A01 CSCL 01A

Flutter analyses were developed to predict the onset of supersonic unstalled flutter of a cascade of two-dimensional airfoils. The first of these analyzes the onset of supersonic flutter at low levels of aerodynamic loading (i.e., backpressure), while the second examines the occurrence of supersonic flutter at moderate levels of aerodynamic loading. Both of these analyses are based on the linearized unsteady inviscid equations of gas dynamics to model the flow field surrounding the cascade. These analyses are utilized in a parametric study to show the effects of cascade geometry, inlet Mach number, and backpressure on the onset of single and multi degree of freedom unstalled supersonic flutter. Several of the results are correlated against experimental qualitative observation to validate the models.

JMS

N79-11001\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AERODYNAMIC AND ACQUISTIC EFFECTS OF ELIMINAT-ING CORE SWIRL FROM A FULL SCALE 1.8 STAGE PRESSURE RATIO FAN (QF-5A)

Richard P. Woodward, Loren W. Acker, and Edward G. Stakolich Sep. 1978 35 p refs

(NASA-TM-78991: E-9774) Avail: NTIS HC A03/MF A01 CSCL DIA

Fan QF-5A was a modification of fan QF-5 which had an additional core stator and adjusted support struts to turn the core exit flow from a 30 deg swirl to the axial direction. This modification was necessary to eliminate the impingement of the swirling core flow on the axial support pylon of the NASA-Lewis Quiet Fan Facility that caused aerodynamic, acoustic and structural problems with the original fan stage at fan speeds greater than 85 percent of design. The redesigned fan QF-5A did obtain the design bypass ratio with an increased core airflow suggesting that the flow problem was resolved. Acoustically, the redesigned stage showed a low frequency broadband noise reduction compared to the results for fan QF-5 at similar operating conditions Author

N79-12015\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF ROTOR TIF CLEARANCE AND CONFIGURA-TION ON OVERALL PERFORMANCE OF A 12.77-CENTIMETER TIP DIAMETER AXIAL-FLOW TURBINE

Jeffrey E. Haas (Army Aviation Research and Development Command) and Milton G. Kofskey 1978 14 p refs To be presented at 24th Ann. Intern. Conf., San Diego, Calif., 11-15 Mar. 1979; sponsored by Am. Soc. of Mech. Engr.

(NASA-TM-79025; E-9181-1; AVRADCOM-TR-78-54)

NTIS HC A02/MF A01 CSCL 01A

The rotor tip clearance was obtained by use of a recess in the casing above the rotor blades and also by use of a reduced blade height. For the recessed casing configuration, the optimum rotor blade height was found to be the one where the rotor tip diameter was equal to the stator tip diameter. The tip clearance loss associated with this optimum recessed casing configuration was less than that for the reduced blade height configuration.

N79-12016\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WIND TURNEL TESTS OF A BLADE SUBJECTED TO MIDCHORD TORSIONAL OSCILLATION AT HIGH SUS-SONIC STALL FLUTTER CONDITIONS

D. R. Betaman and A. E. Buggele Oct. 1978 33 p refs (NASA-TM-78998; E-9782) Avail: NTIS HC A03/MF A01 CSCL 01A

A mechanical drive system for oscillating blades in a wind tunnel at frequencies up to 767 hertz and amplitudes of + or - 1.2 deg is described. High-speed motion pictures of schlieren images of the flow over a double-circular arc blade oscillating in harmonic motion about the midchord revealed extensive shock patterns at a nominal free stream Mach number of 0.7, a mean angle of attack of 4 deg, and reduced frequency of about 0.7. A phase lag resulting from the slow response of the flow to the motion of the blade increased with increasing reduced frequency. This phase lag, based on the difference between the time the blade attained its maximum angle of attack and the time required for the normal shock to reach its extreme downstream position, was nominally 100 deg at the above conditions

N79-12020°# National Aeronautics and Space Administration. Lawis Research Center, Cleveland, Ohio.

AN APPROACH TO OPTIMUM SUBSONIC INLET DESIGN R. W. Luidens, N. O. Stockman, and J. H. Diedrich 1978 14 p. refs Proposed for presentation at the 24th Ann. Intern. Gas Turbine Conf. and 1st Solar Energy Conf., 11-15 Mar. 1979; sponsored by Am. Soc. of Mech. Engr.

(NASA-TM-79051: E-9860) Avail: NTIS HC A02/MF A01 CSCL 01A

Inlet operating requirements are compared with estimated inlet separation characteristics to identify the most critical inlet operating condition. This critical condition is taken to be the design point and is defined by the values of inlet mass flow, free-stream velocity and inlet angle of attack. Optimum flow distributions on the inlet surface were determined to be a high, flat top Mach number distribution on the inlet lip to turn the flow quickly into the inlet and a flat bottom skin-friction distribution on the diffuser wall to diffuse the flow rapidly and efficiently to the velocity required at the fan face. These optimum distributions are then modified to achieve other desirable flow characteristics. Example applications are given.

N79-13083°# National Aeronautics and Space Administration.

Lowis Research Center, Cleveland, Ohio.
AMALYSIS OF SUPERSONIC STALL BENDING FLUTTER IN AXIAL-FLOW COMPRESSOR BY ACTUATOR DISK

John J. Ademczyk Nov. 1978 58 p refs

(NASA-TP-1345; E-9186) Avail: NTIS HC A04/MF A01 CSCL

An analytical model was developed for predicting the onset of supersonic stall bending flutter in axial-flow compressors. The analysis is based on two-dimensional, compressible, unsteady actuator disk theory. It is applied to a rotor blade row by considering a cascade of airfolls. The effects of shock waves and flow separation are included in the model. Calculations show that the model predicts the onset, in an unshrouded rotor, of a bending flutter mode that exhibits many of the characteristics of supersonic stall bending flutter. The validity of the analysis for predicting this flutter mode is demonstrated. Author

N79-14996\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THEORETICAL STUDY OF VTOL TILT-NACELLE AXISYM-METRIC INLET GEOMETRIES

J. Dennis Hawk and Norbert D. Stockman Jan. 1979 29 p.

(NASA-TP-1380; E-9756) Avail: NTIS HC A03/MF A01 CSCL

A systematic theoretical study of VTOL tilt-nacelle inlet design parameters is reported. The manneters considered are internal-lip contraction ratio, internal-lip major-to-minor axis ratio. diffuser-exit-area to throat-area ratio, maximum diffuser wall angle and shape. Each of the inlets was analyzed at the same given flow condition of free-stream velocity, angle between the free stream and centerline of the inlet, and diffuser-exit Mach number. The effects of these geometric parameters on surface staticpressure distribution, peak surface Mach number, diffusion velocity ratio, and tendency for the inlet flow to separate are presented. Author

N79-14998\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AERODYNAMIC PERFORMANCE OF SCARF INLETS

John M. Abbott 1979 22 p refs Presented at 17th Aerospace Sci. Meeting, New Orleans, La., 15-17 Jan. 1979; sponsored by AIAA

(NASA-TM-79055; E-9865) Avail: NTIS HC A02/MF A01

A scarf inlet is characterized by having a longer lower lip than upper lip leading to both serodynamic and acoustic advantages. Aerodynamically, a scarf inlet has higher angle of attack capability and is less likely to ingest foreign objects while the aircraft is on the ground. Acoustically, a scarf inlet provides for reduced inlet radiated noise levels below the engine as a result of upward reflection and refraction of inlet radiated noise. Results of a wind tunnel test program are presented which illustrate the aerodynamic performance of two different scarf inlet designs. Based on these results, scarf inlet performance is summarized in a way to illustrate the advantages and limitations of a scarf inlet compared to an axisymmetric inlet.

N79-14999\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF LIP AND CENTERBODY GEOMETRY ON AERODYNAMIC PERFORMANCE OF INLETS FOR TILTING-NACELLE VTOL AIRCRAFT

Richard R. Burley 1979 27 p Presented at the 7th Aerospace Sci. Meeting, New Orleans, 15-17 Jan. 1979; aponsored by ALLA

(NASA-TM-79056; E-9866; AIAA-Paper-79-0381) Avail: NTIS HC A03/MF A01 CSCL 01A

Inlets for tilt-nacelle VTOL aircraft must operate over a wide range of incidence angles and engine weight flows without internal flow separation. Wind tunnel tests of scale model inlets were conducted to evaluate the effectiveness of three geometric variables to provide this capability Increasing the lip contraction ratio increased the separation angle at all engine weight flows. The optimum axial location of the centerbody occurred when its leading edge was located just downstream of the inlet lip. Compared with a short centerbody, the optimum location of the centerbody resulted in an increase in separation angle at all engine weight flows. Decreasing the lip major-to-minor-axis ratio increased the separation angle at the lower engine weight flows

N79-20069\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WIND TUNNEL PERFORMANCE OF FOUR ENERGY EFFICIENT PROPELLERS DESIGNED FOR O.B CRUISE

Robert J. Jeracki, Daniel C. Mikkelson, and Bernard J. Blaha 1979 24 p refs Presented at the Business Aircraft Meeting. Wichita, Kansas, 3-6 Apr. 1979; sponsored by the Soc. of Automotive Engr.

(NASA-TM-79124: E-9960) Avail: NTIS HC A02/MF A01 CSCL 01A

Several advanced aerodynamic and acoustic concepts were investigated in recent wind tunnel tests performed in the NASA-Lewis Research Center 8x6 foot wind tunnel. These concepts included aerodynamically integrated propeller/nacelles, area-ruling, blade sweep, reduced blade thickness, and power (disk) loadings several times higher than conventional designs. Four eight-hladed propeller models were tested to determine aerodynamic performance. Relative noise measurements were made on three of the models at cruise conditions. Three of the models were designed with swept blades and one with straight blades. At the design Mach number of 0.8, power coefficient of 1.7, and advance ratio of 3.06, the straight bladed model had the lowest net efficiency of 75.8 percent. Increasing the sweep to 30 deg improved the performance to near 77 percent. Installation of an area-ruled spinner on a 30 deg sweep model further improved the efficiency to about 78 percent. The model with the highest blade sweep (45 deg) and an area-ruled spinner had the highest net efficiency of 78.7 percent, and at lower power loadings the efficiency exceeded 80 percent. At lower Mach numbers the 30 deg swept model had the highest efficiency. Values near 81 percent were obtained for the design loading at speeds to Mach 0.7. Relative noise measurements indicated that the acoustically designed 45 deg sweep model reduced the near field cruise noise by between 5 and 6 dB. A.R.H.

N79-23911°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THEORETICAL FAN VELOCITY DISTORTIONS DUE TO INLETS AND NOZZLES

J. Dennis Hawk 1979 12 p refs Presented at the Workshop on V/STOL Aerodyn., Monterey, Calif., 16-18 May 1979 (NASA-TM-79150; E-006) Avail: NTIS HC A02/MF A01 CSCL

Nonuniform velocity profiles imposed on the propulsion system fan can cause fan blade stresses and thrust losses. A theoretical parametric study of the effects of inlets with 0 deg and 90 deg nozzle deflection on the velocity profile at a hypothetical fan is presented. The parameters investigated are fan-to-nozzle spacing and inlet centerline offset. The interaction between the inlet and nozzle is also investigated. The study is made using a twodimensional analysis. A.R.H.

N79-23912\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

Bernard J. Blaha, comp. 1979 147 p refs Workshop held at Cleveland, 19-21 Jul. 1978

(NASA-CP-2086; FAA-RD-78-109; E-027) Avail: NTIS HC A07/MF A01 CSCL 01C

The results of a conference on the problems of aircraft icing are reported. For individual titles, see N79-23913 through N79-23919.

N78-23914° | National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. EXECUTIVE SUMMARY OF AIRCRAFT ICING SPECIALISTS WORKSHOP

Milton A. Beheim In its Aircraft Icing 1979 p 1-16 (For primary document see N79-23912 15-02)

Avail: NTIS HC A07/MF A01 CSCL 01C

In a period of escalating developm (nt costs for new aircraft, there is growing interest in a renewed and coordinated icing research effort to achieve an updating or modernization of each aspect of the technological issues that are involved. This includes the data base, analysis methods, test techniques, and test facilities.

L.S.

N79-23920° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EXPERIMENTAL INVESTIGATION OF FORCED MIXING OF A TURBULENT BOUNDARY LAYER IN AN ANNULAR DIFFUSER Ph.D. Theeis - Ohio State Univ. Robert Joseph Shaw Apr. 1979 182 p refs (NASA-TM-, 9171; E-9947) Avail: NTIS HC A09/MF A01 CSCI 014

The forced mixing process of a turbulent boundary layer in an axisymmetric annular diffuser using conventional wing-like vortex generators was studied. Flow field measurements were made at four axial locations downstream of the vortex generators. At each axial location, a total of 25 equally spaced profiles were measured behind three consecutive vortex generators which formed two pairs of vortex generators. Hot film anemometry probes measured the boundary layer turbulence structure at the same locations where pressure measurements were made. Both single and cross film probes were used. The diffuser turbulence data was teken only for a nominal inlet Mach number of 0.3. Three vortex generator configurations were tested. The differences between configurations involved changes in size and relative vortex generator positions. All three vortex generator configurations tested provided increases in diffuser performance. Distinct differences in the boundary layer integral properties and skin friction levels were noted between configurations. The axial turbulence intensity and Reynolds stress profiles measured displayed similarities in trends but differences in levels for the three configurations.

N79-26019\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAMS FOR CALCULATING TWO-DIMENSIONAL POTENTIAL FLOW THROUGH DEFLECTED NOZZLES

J. Dennis Hawk and Norbert O. Stockman May 1979 316 p refs

(NASA-TM-79144; E-9999) Avail NTIS HC A14/MF A01 CSCL 01A

Computer programs to calculate the incompressible potential flow, corrected for compressibility, in two-dimensional nozzles at arbitrary operating conditions are presented. A statement of the problem to be solved, a description of each of the computer programs, and sufficient documentation, including a test case, to enable a user to run the program are included.

J.M.S.

N79-27093\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF A V/STOL TILT NACELLE INLET WITH SLOWING SOUNDARY LAYER CONTROL

Albert L. Johns, Robert C. Williams, and H. C. Potonides (Grumman Aerospace Corp., Bethpage, N. Y.) 1979 13 p refs Presented at the 15th Joint Propulsion Conf., Las Vegas, Nev., 18-20 Jun. 1979; cosponsored by AIAA, SAE and ASME (NASA-TM-79176; E-043) Avaii: NTIS HC A02/MF A01 CSCL

A .....

A scale model of a V/STOL tilt nacelle fitted to a 0.508 m single stage fan was tested in the NASA Lewis 9x15 ft low speed wind tunnel to determine the effect of diffuser blowing on the inlet aerodynamics and aeromechanical performance. The test was conducted over a range of freestream speeds (up to 120 knots) and angles of attack (up to 120 deg). Diffuser blowing had a beneficial affect on all performance parameters. The angle of attack range for separation free flow substantially increased, and the fan face distortion significantly reduced with a corresponding increase in total pressure recovery. Discrete narrow band blade stress peaks which were common to the nonblowing (baseline) configuration were eradicated with diffuser blowing.

S.E.S

N79-28146°# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

WING AERODYNAMIC LOADING CAUSED BY JET-INDUCED LIFT ASSOCIATED WITH STOLOTH CONFIGURATIONS

U. vonGlahn and D. Groesbeck 1979 40 p refs Presented at Atmospheric Flight Mech. Conf., Boulder, Colo., 6-8 Aug. 1979; sponsored by AIAA

(NASA-TM-79218: E-110) Avail: NTIS HC A03/MF A01 CSCL 01A

Surface pressure distributions were obtained with model-scale STOL-OTW configurations using various nozzles designed to promote flow attachment to the wing/flap surface. The nozzle configurations included slot-types and both circular and slot nozzles with external flow deflectors. The wing aerodynamic loading caused by the jet-induced lift is presented in conventional terms of delta p/q as a function of chordwise surface distance in the nozzle centerline plane as well as outboard of the nozzle centerline. Nozzle roof/deflector angle, chordwise location of the nozzle, wing size, and flap deflection angle are included in the geometric variables affecting the wing loading.

A.R.H.

Norbert O. Stockman 1979 18 p refs Presented at Workshop on V/STOL Aerodyn., Monterey, Calif. 16-18 May 1979; sponsored by Naval Air Develop. Center (NASA-TM-79211, E-096) Avail: NTIS HC A02/MF A01 CSCL

The theoretical analysis methods, potential flow, and boundary layer, used at Lewis are described. Recent application to Navy V/STOL aircraft, both fixed and tilt nacelle configurations, are presented. A three dimensional inlet analysis computer program is described and preliminary results presented. An approach to optimum design of inlets for high angle of attack operations is dicussed.

M.M.M.

A79-12599 \* # Superconic unstalled flutter. J. J. Adamczyk, M. E. Goldstein, and M. J. Hartmann (NASA, Lewis Research Center, Cleveland, Ohio). NATO, AGARD, Meeting of the Propulsion and Energetics Panel, 52nd, Cleveland, Ohio, Oct. 23-27, 1978, Paper. 23 p. 8 refs.

Recently two flutter analyses have been developed at NASA Lewis Research Center to predict the onset of supersonic unstalled flutter of a cascade of two-dimensional airfoils. The first of these analyzes the onset of supersonic flutter at low levels of aerodynamic loading (i.e., backpressure), while the second examines the occur-

rence of supersonic flutter at moderate levels of aerodynamic loading. Both of these analyses are based on the linearized unsteady inviscid equations of gas dynamics to model the flow field surrounding the cascade. The details of the development of the solution to each of these models have been published. The objective of the present paper is to utilize these analyses in a parametric study to show the effects of cascade geometry, inlet Mach number, and backpressure on the onset of single and multi degree of freedom unstalled supersonic flutter. Several of the results from this study are correlated against experimental qualitative observation to validate the models. (Author)

A79-16047 ° # Unsteady flow in a supersonic cascade with subsonic leading-edge locus. J. J. Adamczyk and M. E. Goldstein (NASA, Lewis Research Center, Cleveland, Ohio). AIAA Journal, vol. 16, Dec. 1978, p. 1248-1254, 14 refs.

Linearized theory is used to predict the unsteady flow in a supersonic cascade with subsonic axial flow velocity. A closed-form analytical solution is obtained by using a double application of the Wiener-Hopf technique. Although numerical and semianalytical solutions of this problem have already appeared in the literature, this paper contains the first completely analytical solution. It has been stated in the literature that the blade source should vanish at the infinite duct resonance condition. The present analysis shows that this does not occur. This apparent discrepancy is explained in the paper. (Author)

A79-19452 \* Unsteady vortical and entropic distortions of potential flows round arbitrary obstacles. M. E. Goldstein (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Fluid Mechanics*, vol. 89, Dec. 13, 1978, p. 433-468. 16 refs.

The analysis concerns the alterations produced when small amplitude disturbances, including entropy and vorticity disturbances, are imposed on steady potential flows. For the most general non-acoustic incident distortion field that can be imposed on the uniform upstream flow, it is shown that the perturbation velocity at any point of the resulting unsteady compressible and vortical flow consists of a part that is a known function of the imposed upstream distortion field and the mean flow variables and a potential part that can be found by solving a linear inhomogeneous wave equation with a dipole-type source term whose strength is a known function of the imposed upstream distortion field. The theory is applied to the unsteady flow past a corner, and a closed-form analytical solution is found.

P.T.H.

A79-19495 \* # High speed smoke flow visualization for the determination of cascade shock losses. J. A. Slovisky (Notre Dame, University, Notre Dame, Ind.), W. B. Roberts (Nielsen Engineering and Research, Inc., Mountain View, Calif.), and J. E. Crouse (NASA, Lewis Research Center, Fan and Compressor Branch, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0042. 11 p. 17 refs. Grant No. NsG-3133.

A flow visualization technique has been developed by which quantitative cascade shock loss data can be ascertained without the interference effects of intrusive probes. The technique is first proven feasible by studying the high speed wind tunnel flow around a variety of two-dimensional shapes. Applicability is demonstrated by the testing of a 5% thick sharp-edged flat plate cascade at an upstream Mach number of about 1.3. Results are compared with the relevant theory and total pressure probe data. (Author)

A79-19524 \* # An efficient user-oriented method to \_\_\_\_\_culating compressible flow about three-dimensional inlets. J. L. Hess (Douglas Aircraft Co., Long Beach, Calif.) and N. O. Stockman (NASA, Lewis Research Center, Low Speed Aerodynamics Branch, Cleveland, Ohio). American Institute of Aeronautics and Astronau-

tics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jar. 15-17, 1979, Paper 79-0081. 7 p. Contract No. NAS3-21135.

This method uses a so-called panel method to calculate incompressible flow about arbitrary three-dimensional inlets with or without centerbodies for four fundamental flow conditions: unit onset flows parallel to each of the coordinate axes plus static operation. The computing time is scarcely longer than for a single solution. A linear superposition of these solutions quite rigorously gives incompressible flow about the inlet for any angle of attack, angle of yaw, and mass flow rate. Compressibility is accounted for by applying a well-proven correction to the incompressible flow. Since the computing times for the combination and the compressibility correction are small, flows at a large number of inlet operating conditions are obtained very cheaply. A number of graphical output features are provided to aid the user, including streamline tracing and automatic generation of curves of constant pressure, Mach number, and flow inclination at selected inlet cross sections. This paper describes the method in some detail and presents calculated results. (Author)

A79-19533 \* # Reynolds number, scale and frequency content effects on F-15 inlet instantaneous distortion. C. H. Stevens, E. D. Spong (McDonnell Douglas Corp., St. Louis, Mo.), J. Nugent (NASA, Flight Research Center, Edwards, Calif.), and H. E. Neumann (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0104. 11 p. 6 refs.

An inlet instantaneous distortion study program sponsored by NASA was recently completed using an F-15 fighter aircraft. Peak distortion data from subscale inlet model wind tunnel tests are shown to be representative of full-scale flight test peak distortion. The effects on peak distortion are investigated for engine presence, Reynolds number, scale and frequency content. Data are presented which show that: (1) the effect of engine presence on total pressure recovery, peak distortion, and turbulence is small but favorable, (2) increasing the Reynolds number increases total pressure recovery, decreases peak distortion, and decreases turbulence, and (3) increasing the filter cutoff frequency increases the calculated values of both peak distortion and turbulence. (Author)

A79-23510 \* # Aerodynamic performance of scarf inlets. J. M. Abbott (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0380. 21 p.

A scarf inlet is characterized by having a longer lower lip than upper lip leading to both aerodynamic and acoustic advantages. Aerodynamically, a scarf inlet has higher angle of attack capability and is less likely to ingest foreign objects while the aircraft is on the ground. Acoustically, a scarf inlet provides for reduced inlet radiated noise levels below the engine as a result of upward reflection and refraction of inlet radiated noise. Results of a wind tunnel test program are presented which illustrate the aerodynamic performance of two different scarf inlet designs. Based on these results, scarf inlet performance is summarized in a way to illustrate the advantages and limitations of a scarf inlet compared to an axisymmetric inlet.

(Author)

A79-29007 ° # Evaluation of MOSTAS computer code for predicting dynamic loads in two-bladt d wind turbines. K. R. V. Kaza (NASA, Lewis Research Center, Cleveland; Toledo, University, Toledo, Ohio), D. C. Janetzke, and T. L. Sullivan (NASA, Lewis Research Center, Wind Energy Projects Office, Cleveland, Ohio). In: Structures, Structural Dynamics, and Materials Conference, 20th, St. Louis, Mo., April 4-6, 1979, Technical Papers on Structures and Materials. (A79-29002 11-39) New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 53-63. 13 refs. (AIAA 79-07-33)

Calculated dynamic blade loads are compared with measured loads over a range of yaw stiffnesses of the DOE/NASA Mod-0 wind turbine to evaluate the performance of two versions of the MOSTAS computer code. The first version uses a time-averaged coefficient approximation in conjunction with a multiblade coordinate transformation for two-bladed rotors to solve the equations of motion by standard eigenanalysis. The results obtained with this approximate analysis do not agree with dynamic blade load amplifications at or close to resonance conditions. The results of the second version, which accounts for periodic coefficients while solving the equations by a time history integration, compare well with the measured data. (Author)

A79-30504 \* # Axial-flow compressor turning angle and loss by inviscid-viscous interaction blade-to-blade computation. E. C. Hansen, G. K. Serovy (Iowa State University of Science and Technology, Ames, Iowa), and P. M. Sockol (NASA, Lowis Research Center, Cleveland, Ohio). Arnerican Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-5. 7 p. 27 refs. Members, \$1.50; nonmembers, \$3.00. Grants No. (4sG-3033; No. AF-AFOSR-78-3609; Contract No. F33615-76-C-2090.

A method for computation of the flow field around an arbitrary airfoil cascade on an axially symmetric blade-to-blade surface was developed which takes into account the development and separation of the blade surface boundary layers and mixing in the wake. The method predicts the overall fluid turning and total pressure loss in the context of an inviscid-viscous interaction scheme. The inviscid flow solution is obtained from a compressible flow matrix method. The viscous flow is obtained from a differential boundary layer method which calculates laminar, transitional and turbulent boundary layers. Provisions for the calculation of laminar and turbulent separation regions were added to the viscous scheme. The combined invisid-viscous interaction scheme described yields results which are quantitatively consistent with experimental data. This suggests that the physical basis for the interactive system is correct and justifies continued exploration and use of the method. (Author)

A79-30527 ° # An approach to optimum subsonic inlet design. R. W. Luidens, N. O. Stockman, and J. H. Diedrich (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-51. 10 p. 21 refs. Members, \$1.50; nonmembers, \$3.00.

The approach consists of comparing inlet operating requirements with estimated inlet separation characteristics to identify the most critical inlet operating condition. This critical condition is taken to be the design point and is defined by the valuer of inlet mass flow, free stream velocity, and inlet angle of attack. Optimum flow distributions on the inlet surface are determined to be a high, flat top Mach number distribution on the inlet lip to turn the flow quickly into the inlet and a low, flat bottom skin friction distribution on the diffuser wall to diffuse the flow rapidly and efficiently to the velocity required at the fan face. These optimum distributions are then mod/fied to achieve other desirable flow characteristics. Example applications are given. Extension of the method is suggested. (Author)

A79-39810 ° # Theoretical fan velocity distortions due to inlets and nozzles. J. D. Hawk (NASA, Lewis Research Center, Cleveland, Ohio). Workshop on V/STOL Aerodynamics, Munterey, Calif., May 16-18, 1979, Paper. 10 p.

Nonuniform velocity profiles imposed on the propulsion system fan can cause fan blade stresses and thrust losses. This paper presents a theoretical parametric study of the effects of inlets with 0 deg and 90 deg nozzle deflection on the velocity profile at a hypothetical fan. The parameters investigated are fan-to-nozzle spacing and inlet centerline offset. The interaction between the inlet and nozzle is also investigated. The study is made using a two-dimensional analysis.

(Author)

A79-47346 \* # Wing serodynamic loading caused by jetinduced lift associated with STOL-OTW configurations. U. von Glahn and D. Groetback (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Atmospheric Flight Mechanics Conference, Boulder, Colo., Aug. 6-8, 1979, Paper 79-1664, 38 p. 5 refs.

Surface pressure distributions were obtained with model-scale STOL-OTW configurations using various noziles designed to promote flow attachment to the wing-flap surface. The nozzle configurations included slot-types and both circular and slot nozzles with external flow deflectors. The wing aerodynamic loading caused by the jet-induced lift is presented in conventional terms of delta p/q as a function of chordwise surface distance in the nozzle centerline plane as well as outboard of the nozzle centerline. Included in the geometric variables affecting the wing loading are nozzle roof/deflector angle, chordwise location of the nozzle, wing size, and flap deflection angle. (Author)

A79-47347 \* # Purformance of a V/STOL tilt nacelle inlet with blowing boundary layer control. A. L. Johns, R. C. Williams (NASA, Lewis Research Center, Cleveland, Ohio), and H. C. Potonides (Grumman Aerospace Corp., Bethpage, N.Y.). A/AA, SAE, and ASME, Joint Propulsion Conference, 15th, Les Veges, Nev., June 18-20, 1979, A/AA Paper 79-1163. 11 p. 5 refs.

A scale model of a V/STOL tilt nacelle fixted to a 0.508 m single stage fan was tested in the NASA Lowis low speed wind tunnel to determine the effect of diffuser blowing on the inlet aerodynamics and aeromechanical performance. The test was conducted over a range of freestream speeds (up to 120 knots) and angles-of attack (up to 120 deg). In general, diffuser blowing had a beneficial affect on all performance parameters. The angle-of-attack range for a separation-free flow substantially increased, and the fan face distortion reduced with a corresponding increase in total pressure recovery. Discrete narrow band blade stress pecks which were common to the nonblowing (baseline) configuration were eradicated with diffuser blowing.

A79-49530 \* # Recent applications of theoretical analysis to V/STOL inlet design. N. O. Stockman (NASA, Lewis Research Center, Cleveland, Ohio). U.S. Navy, Workshop on V/ST/JL Aero-dynamics, Monterey, Calif., May 16-18, 1979, Paper, 16 p. 17 refs.

A brief description of the axisymmetric potential flow and boundary layer analysis methods used at the Nasa Lewis Research Center, is presented. Application of this method to inlet problems arising from both tilt-nacelle and fixed-nacelle V/STOL aircraft configurations is illustrated. A three-dimensional inlet analysis computer program is described and the preliminary results presented. Finally, a suggested approach to optimum design of inlets for high angle-of-attack operation is discussed.

N78-12014 FGeneral Dynamics/Fort Worth, Tex.
EXPERIMENTAL INVESTIGATION OF A 0.15-SCALE MODEL
OF AN UNDERFUSELAGE NORMAL-SHOCK INLET
Final Report

P. C. Learner and I. G. Kennon 1978 332 p refs (Contract NAS3-21139)

(NASA-CR-3049) Avail: NTIS HC A15/MF A01 CSCL 01A. A 0.15 scale model of an underfuselage inlet designed for a single-engine fighter airplane was tested. The inlet was a fixed-geometry, normal-shock configuration designed to operate at flight speeds up to Mach 2.0. Petormance data for the basic inlet and several configuration variations are presented as a function of angle of attack, angle of sideslip, and airflow in the 0.6 to 2.0 Mach number range. The configuration variations included boundary-layer diverter height, cowl and splitter-plate modifications, and inlet bleed system variations. Flow-field characteristics at the simulated engine face, at the inlet throat, at the splitter-plate leading edge, and forward of the inlet are presented. The pressure recovery of the inlet is approximately equal to the product of theoretical normal-shock and duct pressure recoverable at cruise angle of attack. Very good performance at

high angle of attack was obtained. Pressure distortion and turbulence at the engine face were low, and the inlet remained stable at all angine airflows over the flight maneuver envelope of the aircraft for which the inlet was designed. G.G.

# O3 AIR TRANSPORTATION AND

Includes passenger and cargo air transport operations; and aircraft accidents.

For related information see also 16 Space Transportation and 85 Urban Technology and Transportation.

N79-15013°# National Aeronautics and Space Administration.

AIRCRAFT CABIN OZONE MF QUREMENTS ON 8747-100
AND \$2747-SP AIRCRAF CORRELATIONS WITH
ATMOSPHERIC OZONE AND OZONE ENCOUNTER
STATISTICS

Porter J. Farkins, J. D. Holdeman, and Daniel J. Gauntner Jan. 1978 41 p refs Presented at a Tech. Briefing on Ozone, Cleveland, Ohio, 19 Jan. 1978

(NASA-TM-79060: E-9875) Avail NTIS HC A03/MF A01 CSCL 05F

Simultaneous measurements of atmospheric (outside) ozone concentration and ozone levels in the cabin of the B747-100 and B747-SP airliners were made by NASA to evaluate the aircraft cabin ozone contamination problem. Instrumentation on these aircraft measured ozone from an outside probe and at one point in the cabin. Average ozone in the cabin of the B747-100 was 39 percent of the outside. Ozone in the cabin of the B747-SP measured 82 percent of the outside, before corrective measures. Procedures to reduce the ozone in this aircraft included changes in the cabin air circulation system, use of the hightemperature 15th stage compressor bleed, and charcoal filters in the inlet cabin air ducting, which as separate actions reduced the ozone to 58, 19 and 5 percent, respectively. The potential for the NASA instrumented 8747 aircraft to ancounter high levels of cabin ozone was derived from atmospheric oxone measurements on these aircraft. Encounter frequencies for two B747-100's were comparable even though the route structures were different. The B747-SP encountered high ozone than did the B747-100's

Author

OZONE CONTAMINATION IN AIRCRAFT CABINS: OBJECTIVES AND APPROACH

Porter J. Perkins In its Czone Contamination in Aircraft Cabino Mar. 1979 p 1-2 (For primary document see N79-21021 12-03) Avail: NTIS HC A05/MF A01 CSCL 06S

Three panels were developed to solve the problem of ozone contamination in aircraft cabins. The problem is defined from direct in-flight measurements of ozone concentrations inside and outside airliners in their normal operations. Solutions to the cabin ozone problem are discussed under two areas: (1) flight planning to awoid high ozone concentrations, and (2) ozone destruction techniques installed in the cabin air systems. S.E.S.

N79-21025° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OZONE CONTAMINATION IN AIRCRAFT CARINS: SUMMARY OF RECOMMENDATIONS

Porter J. Perkins *In its* Ozone Contamination in Aircraft Cabins Mar. 1979 p 11-12 (For primary document see N79-21021 12-03)

Avail: NTI3 HC A05/MF A01 CSCL 06S

Recommendations from the three panels on in-flight measurements, hight planning to avoid high ozone, and ozone destruction techniques are summarized.

S.E.S.

N79-21027\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Onio.

OZONE CONTAMINATION IN AIRCRAFT CABINS: POST WORKSHOP REVIEW OF RECOMMENDATIONS

Porter J. Perkins In its Ozone Contamination in Aircraft Cabins Mar. 1979 p 13-16 (For primary document see N79-21021 12-03)

Avail: NTIS HC A05/MF A01 CSCL 06S

The recommendations, level of priority for accomplishment, and recommended approaches and responsibility for implementation as established by the review are presented.

S.E.S.

N79-21029\* National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

OZONE CONTAMINATION IN AIRCRAFT CABINS. APPENDIX 8: OVERVIEW PAPERS, IN-FLIGHT MEASURE-MENTS

Porter J. Perkins In its Ozone Contamination in Aircraft Cabins Mar. 1979 p 21-29 (For primary document see N79-21021 12-03)

Avail: NTIS HC A05/MF A01 CSCL 06S

The NASA Global Atmospheric Sampling Program ozone measurements were obtained to establish to characteristics of the ambient ozone concentration during routine operations and to determine the attenuation of ambient concentrations of cabin air systems from simultaneous ambient and in cabin measurements. The characteristics of ambient ozone include: (1) maximum concentration; (2) duration of ozone encounters; (3) frequency of ozone during a flight: (4) variability of ozone during a flight: (5) in relation to routes, altitude, and meteorological conditions.

SES

N79-33171\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PROCEDURES FOR ESTIMATING THE FREQUENCY OF COMMERCIAL AIRLINE FLIGHTS ENCOUNTERING HIGH CABIN OZONE LEVELS

James D. Holdeman Oct. 1979 56 p. refs (NASA-TP-1560; E-9991) Avail: NTIS HC A04/MF A01 CSCL

Three analytical problems in astimating the frequency at which commercial airline flights will encounter high cabin ozone levels are formulated and solved, namely, estimating flight-segment mean levels, estimating maximum-per-Right levels, and estimating the maximum average level over a specified flight interval. For each problem, solution procedures are given for different levels of input information - from complete cabin ozone data, which provides a direct solution, to limited ozone information, such as ambient ozony means and standard deviations, with which several assumptions are necessary to obtain the required estimates. Each procedure is illustrated by an example case calculation that uses simultaneous cabin and ambient ozone data obtained by the NASA Global Atmospheric Sampling Program. Critical assumptions are discussed and evaluated, and the several solutions for each problem are compared. Example calculations are also performed to illustrate how variations in lattitude, altitude, season, retention ratio, flight duration, and cabin ozone limits affect the Author estimated probabilities

A79-27571 \* Simultaneous measurements of ozone outside and inside cabins of two B-747 airliners and a Gates Learjet business jet. P. J. Perkins and D. Briehl (NASA, Lewis Research Center, Cleveland, Ohio). In: Conference on Atmospheric Environment of Aerospace Systems and Applied Meteorology, New York, N.Y., November 14-16, 1978, Preprints. (~79-275), 3 10-47) Boston, Mass., American Meteorological Society, 1978, p. 39-44, 15 refs.

Recently, passengers and crew members on long-distance commercial flights have filed complaints after suffering symptoms of ozone sickness. Studies were conducted to determine the frequency and concentration of ozone in commercial jet transports. The airliner problem with ozone prompted NASA to determine the ozone concentrations that might be encountered in the cabin of a small business jet. Simultaneous measurements of atmospheric ozone levels

and ozone levels in the cabins of jet aircraft were necessary because of the wide and rapid variability of atmospheric ozone in flight. It was found that the atmospheric ozone concentrations in the case of B-747 airliners vary widely during a flight. A constant difference, or ratio, between ozone concentrations outside and inside the cabin does not exist.

G.R.

N79-23940° 

# Boeing Commercial Airplane Co., Seattle, Wash.
INFLIGHT FUEL TANK TEMPERATURE SURVEY DATA Final
Report

A. J. Pasion May 1979 60 p refs (Contract NAS3-20815) (NASA-CR-159569: D6-48611)

Avail: NTIS

HC A04/MF A01 CSCL 01C

Statistical summaries of the fuel and air temperature data for twelve different routes and for different sircraft models (8747, 8707, DC-10 and DC-8), are given. The minimum fuel, total air and static air temperature expected for a 0.3% probability were summarized in table form. Minimum fuel temperature extremes agreed with calculated predictions and the minimum fuel temperature did not necessarily equal the minimum total air temperature even for extreme weather, long range flights, R.E.S.

## O4 AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

For related information see also 17 Spacecraft Communications, Command, and Tracking and 32 Communications.

N79-31185\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

UHF COPLANAR-SLOT ANTENNA FOR AIRCRAFT-TO-SATELLITE DATA COMMUNICATIONS

Poyce W: Myhre 1979 21 p refs Presented at the Printed Circuit Antenna Technol. Workshop, Las Cruces, N. Mex., 17-19 Oct. 1979; sponsored by New Mexico State Univ. and the Army Res Office Physical Sci. Lab.

(NASA-TM-79239; 5-146) Avail: NTIS HC A02/MF A01 CSCL 176

A lightweight low drag connar slot antenna was developed for use an commercial jet aircraft that will provide upper hemisphere coverage in the UHF band at frequencies of 402 and 468 fMz is described. The antenna is designed to transmit meteorological data from wide body jet aircraft to ground users via synchronous meteorological data relay satellites. The low profile antenna (23.5 cm wide by 38.1 cm long slot by 1.9 cm high) is a conformal anterina utilizing the coplanar approach with the advantages of broad frequency bandwidth and improved electrical integrity over wide range of temperature. The antenna is circular polarized, has anon axis gain of near +2.5 dB, and a HPBW greater than 90 deg. Areas discussed include antenna design, radiation characteristics, flight testing, and system performance.

N79-33186\*# Netional Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MULTIPLE SPEED EXPANDABLE BIT SYNCHRONIZER

James M. Bundinger Aug. 1979 13 p. refs

(NASA-TM-79262; E-176) Avail: NTIS HC A02/MF A01 CSCL 17G

A multiple speed bit synchronizer was designed for installation in an inertial navigation system data decoder to extract non-return-to-zero level data and clock signal from biphase level data. The circuit automatically senses one of four pre-determined biphase data ates and synchronizes the proper clock rate to the data. Through a simple expansion of the basic design, synchronization of noise than four binarily related data rates can be accomplished. The design provides an easily adaptable, low cost, low power ulternative to external bit synchronizers with additional savings in size and weight.

A79-14949 \* An airborne meteorological data collection system using satellite relay /ASDAR/. J. W. Bagwell and B. G. Lindow (NASA, Lewis Research Center, Cleveland, Ohio). Instrument Society of America, International Telemetering Conference, Los Angeles, Calif., Nov. 14-16, 1978, Paper. 16 p.

The paper describes the aircraft to satellite data relay (ASDAR) project which processes information collected by the reavigation and data systems of widebody jet aircraft which cross data-sparse areas of the tropics and southern hemisphere. The ASDAR system consists of a data acquisition and control unit to acquire, store, and format latitude, longitude, altitude, wind speed, wind direction, and outside air temperature data; a transmitter to relay the formatted data via satellite to the ground, and a clock to time the data sampling and transmission periods.

A79-17092 \* Automated meteorological data from commercial aircraft via satellite - Present experience and future implications. R. Steinberg (NASA, Lewis Research Center, Cleveland, Ohio). In: International Conference on Maritime and Aeronautical Satellite Communication and Navigation, London, England, March 7-9, 1978, Proceeding. (A79-17086 05-04) London, Institution of Electrical Engineers, 1978, p. 33-36.

The National Aeronautics and Space Administration has developed a low-cost communications system to provide meteorological data from commercial aircraft, in near real-time, on a fully automated basis. The complete system including the low profile antenna and all installation hardware weighs 34 kg. The prototype system has been installed on a Pan American B-747 aircraft and has been providing meteorological data (wind angle and velocity, temper\_ture, altitude and position as a function of time) on a fully automated basis for the past several months. The results have been exceptional. This concept is expected to have important implications for operational meteorology and airline route forecasting. (Author)

## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.
For related information see also 18 Spacecraft Design,
Testing and Performance and 39 Structural Mechanics.

N79-24976\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SELF STABILIZING SONIC INLET Patent
Brent A. Miller, inventor (to NASA) Issued 15 May 1979 5 p
Filed 29 Mar. 1978
(NASA-Case-LEW-11890-1; US-Patent-4,154,256;
US-Patent-Appl-SN-891244; US-Patent-Class-137-15.1;
US-Patent-Class-244-53B) Avail: US Patent and Trademark
Office CSCL 01C

An inlet suitable for a turbine engina in a STOL, VTOL or CTOL aircraft is described. A circumferentially extended slot is provided in the inner surface of the air inlet at the windward side and downstream of the throat region. The slot communicates with a circumferential plenum chamber formed in the front of the air inlet just behind the lip. Circumferentially extending rows of apertures are provided on the lip establishing two sets of apertures spaced circuit reentially away from the slot in opposite directions. The slot removes the boundary layer from the critical portion of the diffuser to minimize or eliminate flow pressure loss or separations resulting from diffusion or tuning. The apertures are in a region of low static pressure on the lip of the inlet and serve as a source of suction to cause air flow into the slot.

Official Gazette of the U.S. Patent and Trademark Office

A79-28970 \* # Investigation of wing shielding effects on CTOL engine noise. H. E. Bloomer (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0609. 33 p. 9 refs.

A full scale engine wing shielding investination was conducted at the Lewis Research Center using a 97,9° N (22,000 lb) thrust turbofan engine and a simulated wing section sized around a conventional-take-off type four-engine narrow body airplane. Sound data were obtained for the wing placed at seven positions in a plane parallel to the engine axis, and were compared to data obtained without the wing at both take off and approach power. In addition the engine was operated with and without extensive acoustic treatment including a sonic inlet in order to evaluate wing shielding effectiveness with a highly suppressed engine. The wing shielding effectiveness was also calibrated using a 3.8 cm diam air nozzle as a sound source. Results indicated that ever though about 10 dB broad band shielding was achieved, the equivalent flyover noise reduction was less than 3.0 EPNdB for most configurations. (Author)

### **06** AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

For related information see also 19 Spacecraft Instrumentation and 35 Instrumentation and Photography.

N79-23963\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMBINED PRESSURE AND TEMPERATURE DISTORTION EFFECTS ON INTERNAL FLOW OF A TURBOFAN ENGINE W. M. Braithwaite and Ronald H. Soeder 1979 19 p refs Presented at the 15th Joint Propulsion Conf., Las Vegas, 18-20 Jun. 1979; cosponsored by AIAA, the Soc. of Automotive Engr., and ASME

(NASA-TM-79136: E-9984) Avail: NTIS HC A02/MF A01 CSCL 21E

An additional data base for improving and verifying a computer simulation developed by an engine manufacturer was obtained. The multisegment parallel compressor simulation was designed to predict the effects of steady-state circumferential inlet total-pressure and totai-temperature distortions on the flows into and through a turbofan compression system. It also predicts the degree of distortion that will result in surge of the compressor. The effect of combined 180 deg square-wave distortion patterns of total pressure and total temperature in various relative positions is reported. The observed effects of the combined distortion on a unitary bypass ratio turbofan engine are presented in terms of total and static pressure profiles and total temperature profiles at stations ahead of the inlet guide vanes as well as through the fan-compressor system. These observed profiles are compared with those predicted by the complex multisegment model. The effects of relative position of the two components comprising the combined distortion on the degree resulting in surge are discussed. Certain relative positions required less combined distortion than either a temperature or pressure distortion by SES itself

N79-23966\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Onio.

EFFECT OF DEGREE OF FUEL VAPORIZATION UPON EMISSIONS FOR A PREMIXED PREVAPORIZED COMBUSTION SYSTEM

L. P. Cooper 1979 17 p refs Presented at the 15th Joint Propulsion Conf. Las Vegas, 18-20 Jun. 1979; cosponsored by AIAA, SAE and ASME

(NASA-TM-79154, E-010) Avail NTIS HC A02/MF A01 CSCL 21E

An experimental and analytical study of the combustion of partially vaporized fuelair mixtures was performed to assess the impact of the degree of fuel vaporization upon emissions for a premixing-prevaporizing flametube combustor. Data collected show near linear increases in nitrogen oxide emissions with decreasing vaporization at equivalence ratios of 0.6. For equivalence ratio of 0.72, the degree of vaporization had very little impact on nitrogen oxide emissions. A simple mechanism which accounts for the combustion of liquid droplets in partially vaporized mixtures was found to agree with the measured results with fair accuracy with respect to both trends and magnitudes.

Author

A79-50333 \* Airborne atmospheric templing system. U. R. C. Gustafsson (United Airlines, Inc., San Francisco, Calif.), P. J. Perkins, T. W. Nyland, M. W. Tiefermann, and T. J. Dudzinski (NASA, Lewis Research Center, Cleveland, Ohio). In: Learning to use our environment; Proceedings of the Twenty-fifth Annual Technical Meeting. Seattle, Wash., April 30-May 2, 1979. (A79-50326-22-42) Mount Prospect; III., Institute of Environmental Sciences, p. 48-57.

The atmospheric sampling system developed for use on board commercial airliners as part of the Global Atmospheric Sampling Program (GASP) is described. The automated air-constituent measur-

ing system is installed in a Boeing 747 airliner below the passenger cabin floor near the nose wheel well. It consists of an air sample flow system, composed of air inlet and pressurization systems, computerized data acquisition and system control units which direct system operation in 15 modes, and commercial instruments significantly modified to measure low levels of atmospheric constituents (ozone, water vapor, nitrogen oxides, carbon monoxide, chlorofluoromethanes, particulates, condensation nuclei, sulfates and nitrates). Flight and meteorological data, including air temperature and altitude, are also recorded. The system is designed for servicing at 14-day intervals, and to require a minimum of aircrew involvement.

A.L.W.

N79-12084\* Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
ENERGY EFFICIENT ENGINE PRELIMINARY DESIGN AND INTEGRATION STUDY

D. E. Gray et al Nov. 1978 36? p (Contract NAS3-20628)

(NASA-CR-135396: PWA-5500-18)

HC A16/MF A01 CSCL 21E

The technology and configurational requirements of an all new 1990's energy efficient turbofan engine having a twin spool arrangement with a directly coupled fan and low-pressure turbine. a mixed exhaust nacelle, and a high 38.6:1 overall pressure ratio were studied. Major advanced technology design features required to provide the overall benefits were a high pressure ratio compression system, a thermally actuated advanced clearance control system, lightweight shroudless fan blades, a low maintenance cost one-stage high pressure turbine, a short efficient mixer and structurally integrated engine and nacelle. A conceptual design analysis was followed by integration and performance analyses of geared and direct-drive fan engines with separate or mixed exhaust nacelles to refine previously designed engine cycles. Preliminary design and more detailed engine-aircraft integration analysis were then conducted on the more promising configurations. Engine and aircraft sizing, fuel burned, and airframe noise studies on projected 1990's domestic and international aircraft produced sufficient definition of configurational and advanced technology requirements to allow immediate initiation of component technology development.

A.R.H

Avail:

NTIS

N79-12087\* Battelle Columbus Labs. Ohio.
COMPUTER-AIDED ANALYSIS AND DESIGN OF THE
SMAPE ROLLING PROCESS FOR PRODUCING TURBINE
ENGINE AIRFOILS Final Report, 1 Oct. 1976 - 30 Jun.
1978

G D Lahoti, N. Akgerman, and T. Altan Dec. 1978 251 p. refs

(Contract NAS3-20380)

(NASA-CR-159445) Avail: NTIS HC A12/MF A01 CSCL 21E

Mild steel (AISI 1018) was selected as model cold rolling material and Ti-6A1-4V and Inconel 718 were selected as typical hot rolling and cold rolling alloys, respectively. The flow stress and workability of these alloys were characterized and friction factor at the roll/workpiece interface was determined at their respective working conditions by conducting ring tests. Computer-aided mathematical models for predicting metal flow and stresses, and for simulating the shape rolling process were developed. These models utilized the upper bound and the slab methods of analysis, and were capable of predicting the lateral spread, roll separating force, roll torque, and local stresses, strains and strain rates. This computer-aided design system was also capable of simulating the actual rolling process, and thereby designing the roll pass schedule in rolling of an airfoil or a JAM similar shape.

### **07** AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

For related information see also 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels, and 44 Energy Production and Conversion.

N79-10057\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

APPARATUS AND METHOD FOR REDUCING THERMAL

STRESS IN A TURBINE ROTOR Patent

Jack A. Heller, inventor (to NASA) Issued 3 Oct. 1978 6 p Filed 4 Mar. 1977 Supersedes N77-18160 (15 - 09, p 1135) (NA SA-Case-LEW-12232-1; US-Patent-4,117,669;

US Patent-Appl-SN-776029; US-Patent-Class-60-39.14; US-Patent-Class-415-115; US-Patent-Class-415-116) Avail: US

Patent Office CSCL 21E

A gas turbine is described wherein the thermal stresses in the turbine rotor are reduced. The rotor includes a central disc with a peripheral rim, and a plurality of blades extending radially outward from the rim. To reduce thermal stresses, a duct arrangement is provided which selectively directs hot gases from the turbine combustor to the rim during the turbine start up. The hot gases from the combustor serve to heat the rim, and decrease the start up period necessary to bring the temperature profile of the rotor into the operating temperature range. After the start up period, the duct arrangement is then used to direct cool gases from the turbine compressor to the rim of the rotor in order to maintain a lower rotor equilibrium temperature.

Official Gazette of the U.S. Patent Office

N79-10060°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF SINGLE-STAGE AXIAL-FLOW TRAN-SONIC COMPRESSOR WITH ROTOR AND STATOR ASPECT RATIOS OF 1.19 AND 1.26, RESPECTIVELY, AND WITH **DESIGN PRESSURE RATIO OF 1.82** 

Lonnie Reid and Royce D. Moore Nov. 1978 103 p refs (NASA-TP-1338; E-9461) Avail: NTIS HC A06/MF A01 CSCL

The overall and blade-element performance of a luw-aspectratio transonic compressor stage is presented over the stable operating flow range at 70, 90, and 100 percent design speeds. At design speed the rotor and stage achieved peak efficiencies of 0.872 and 0.845 at pressure ratios of 1.875 and 1.842. respectively. The stage stall margin at design speed was 21.8 percent.

N79-11043\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

INFRARED SUPPRESSOR EFFECT ON T63 TURBOSHAFT **ENGINE PERFORMANCE** 

Evereit E Builey, Kestutis C Civinskas, and Curtis L Walker Sep 1978 14 p ref

(NASA-TM-78970, E-9730, AVRADCOM-TR-78-38(PL)) Avail. NTIS HC A02/MF A01 CSCL 21E

Tests were conducted to determine if there are performance penalties associated with the installation of infrared (IR) suppressors on the T63-A-700 turboshaft engine. The testing was done in a sea-level, static test cell. The same engine (A-E402808 B) was run with the standard OH-58 aircraft exhaust stacks and with the ejector-type IR suppressors in order to make a valid comparison. Repeatability of the test results for the two configurations was verified by rerunning the conditions over a period of days. Test results showed no measurable difference in performance between the standard exhaust stacks and the IR suppressors Author

N79-11057\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
GAS PATH SEALING IN TURBINE ENGINES

Lawrence P Ludwig In AGARD Seal Technol in Gas Turbine Eng. Aug. 1978 41 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01 CSCL 21E

Gas path seals are discussed with emphasis on sealing clearance effects on engine component efficiency, compressor pressure ratio, and stall margin. Various case-rotor relative displacements, which affect gas path seal clearances, are identified. Forces produced by nonuniform sealing clearances and their effect on rotor stability are examined qualitatively, and recent work on turbine-blade-tip scaling for high temperatures is described. The need for active clearance control and for engine structural analysis is discussed. The functions of the internal-flow system and its seals are reviewed ARH

N79-11070°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SELF-ACTING SHAFT SEALS

Lawrence P. Ludwig In AGARD Seal Technol in Gas Turbine Eng. Aug. 1973 29 p refs (For primary document see N79-11056

Avail NTIS HC A13/MF A01 CSCL 131

The operating principle and design of the self-acting seal is reviewed. Mathematical models for obtaining a seal force balance and the equilibrium operating film thickness are outlined. Particular attention is given to primary ring response (seal vibration) to rotating seat face runout. This response analysis reveals three different vibration modes with secondary seal friction being an important parameter. Leakage flow inlet pressure drop and affects of axisymmetric and nonaxisymmetric sealing face deformations are discussed. Experimental data on self-acting face seals operating under simulated gas turbine conditions are given; these data show the feasibility of operating the seal at conditions of 345 N sq cm (500 psi) and 152 m/sec (500 ft/sec) sliding speed. Also, a spiral groove seal design operated to 244 m/sec (800 ft/sec) is described. ARH

N79-12083°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Onio.

PRELIMINARY STUDY OF OPTIMUM DUCTBURNING TURBOFAN ENGINE CYCLE DESIGN PARAMETERS FOR SUPERSONIC CRUISING

Laurence H. Fishbach Nov. 1978 26 p refs (NASA-TM-79047; E-9856) Avail: NTIS HC A03/MF A01 CSCL 21E

The effect of turbofan engine overall pressure ratio, fan pressure ratio, and ductburner temperature rise on the engine weight and cruise fuel consumption for a mach 2.0 supersonic transport was investigated. Design point engines, opt mized purely for the supersonic cruising portion of the flight where the bulk of the fuel is consumed, are considered. Based on constant thrust requirements at cruise, fuel consumption considerations would favor medium by pass ratio engines (1.5 to 1.8) of overall pressure ratio of about 16. Engine weight considerations favor low bypass ratio (0.6 or less) and low wverall pressure ratio (8). Combination of both effects results in bypass ratios of 0.6 to 0.8 and overall pressure ratio of 12 being the overall optimum.

N79-12085\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF FLIGHT LOADS ON TURBOFAN ENGINE PERFORMANCE DETERIORATION

E. G. Stakolich, A. Jay (Pratt and Whitney Aircraft, East Hartford, Conn.), E. S. Todd (Pratt and Whitney Aircraft, East Hartford, Conn.), P. G. Kafka (Boeing Com. Airplane Co., Renton, Wash.), and J. L. White (Boeing Com. Airplane Co., Renton, Wash.) 1978 22 p refs Proposed for presentation at the 24th Ann. Intern. Gas Turbine Conf., San Diego, Calif., 11-15 Mar. 1979; sponsored by the Am. Soc. of Mech. Engr. (NASA-TM-79041; E-9844) Avail: NT:S HC A02/MF A01

CSCL 21E

A significant percentage of high bypass ratio, turbofan engine performance deterioration was caused by an increase in operating clearance between fan/compressor and turbine blades and their outer air seals. These increased clearances resulted from rubs induced by a combination of engine power transients and aircraft flight loads. An analytical technique for predicting the effect of quasi-steady state aircraft flight loads on engine performance deterioration was developed and is presented. Thrust, aerodynamic and inertia loads were considered. Analytical results are shown and comparad to actual engine test experience.

J.A.M.

N79-12086\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASA RESEARCH ON GENERAL AVIATION POWER

Warner L. Stewart, Richard J. Weber, Edward A. Willis, and Gilbert K. Sievers 1978 14 p refs Proposed for presentation at the 15th Ann. Meeting and Tech. Display. Washington, D. C. 5-8 Feb. 1979; sponsored by AIA 4

(NASA-TM-79031; E-9828) Avail. NTIS HC A02/MF A01 CSCL 21A

Propulsion systems are key factors in the design and performance of goneral aviation airplanes. NASA research programs that are intended to support improvements in these engines are described. Reciprocating engines are by far the most numerous powerplants in the aviation fleet; near-term efforts are being made to lower their fuel consumption and emissions. Longer-term work includes advanced alternatives, such as rotary and lightweight diesel engines. Work is underway on improved turbofans and turboprops.

Author

N79-13046\* National Aeronautics and Space Administration. Lewis Research Center, Clevaland, Ohio.

LOW-CYCLE FATIGUE G7 THERMAL-BARRIER COATINGS AT 982 DEG C

Albert Kaufman, Curt H. Liebert, and Alfred J. Nachtigall Dec. 1978 20 p. refs

(NASA-TP-1322; E-9688) Avail: NTIS HC A02/MF A01 CSCL 21E

The low-cycle fatigue lives of ZrO2-Ni^rAlY and Al2O3-ZrO2-NiCrAlY thermal-barrier coetings in air at 982 C were determined from cyclic flexural tests of coated TAZ-8A strips. Strains were computed as a function of specimen displacements from a nonlineer, three-dimensional stress analysis program. Fatigue resistances of thermal-barrier coatings applied to the strips were compared with those of uncoated and NiCrAlY-coated strips. The results indicate that ZrO2 is about four times greater in fatigue life than TAZ-8A at 982 C, that ZrO2 would probably

N79-13049° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COLD-AIR PERFORMANCE OF FREE POWER TURBINE DESIGNED FOR 112-KILOWATT AUTOMOTIVE GASTURBINE ENGINE 3: EFFECT OF STATOR VANE END CLEARANCES ON PERFORMANCE

Milton G. Kofskey and Kerry L. McLallin Dec. 1978 41 p

(Contract EC-77-A-31-1011)

(NASA-TM-78956: DOE/NASA/1011-78/29) Avail: NTIS HC A03/MF A01 CSCL 21A

An experimental investigation of a free power turbine designed for a 112-kW, automotive, gas turbine engine was made to determine the penalty in performance due to the stator vane end clearances. Tests were made over a range of mean section stator vane angles from 26 deg to 50 deg (as measured from the plane of rotation) with the vane end clearances filled. These results were compared with test results of the same turbine with vane end clearances open. At design equivalent values of rotative speed and pressure ratio and at a vane angle of 35 deg, the mass flow with the vane and clearances filled was about 8 percent lower than mass flow with vane end clearances open. The decrease in mass flow was mitigated by increasing the

N79-14095° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CAM-OPERATED PITCH-CHANGE APPARATUS Patent
Philip E. Barnes, inventor (to NASA) (United Technologies Corp.,
Windsor Locks, Conn.) Issued 7 Nov. 1978 8 p Filed 9 Oct.
1974 Published under the second Trial Voluntary Protest Program
as B 513, 346, 9 Mar. 1976 Sponsored by NASA
(NASA-Case-LEW-13050-1; US-Patent-4,124,330;
US-Patent-Appl-SN-513346; US-Patent-Class-416-1578;

US-Patent-Class-416-162; US-Patent-Class-416-160;

US-Patent-Class-416-167) Avail: US Patent and Trademark Office CSCL 01C

A pitch-change apparatus for a ducted thrust fan having a plurality of variable pitch blades employs a camming ring mounted coaxially at the hub at an axially fixed station along the hub axis for rotation about the hub axis both with the blades and relative to the blades. The ring has a generally spherical outer periphery and a plurality of helical camming grooves extending in a generally spherical plane on the periphery. Each of the variable pitch blades is connected to a pitch-change horn having a cam follower mounted on its outer end, and the camming ring and the horns are so arranged about the hub axis that the plurality of followers on the horns engage respectively the plurality of helical camming grooves. Rotary drive means rotates the camming ring relative to the blades to cause blade pitch to be changed through the cooperative operation of the camming grooves on the ring and the cam followers on the pitch-change homs Official Gazette of the U.S. Patent and Trademark Office

N79-14096° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INTEGRATED GAS TURBINE ENGINE-NACELLE Patent Arthur P. Adamson (GE, Cincinnati), Donald F. Sargisson (GE, Cincinnati), and Charles L. Stotler, Jr., inventors (to NASA) (GE, Cincinnati) Issued 2 Jan. 1979 9 p. Filed 22 Dec. 1976 Continuation of abandoned US Patent Appl. SN-522106, filed 8 Nov. 1974 Sponsored by NASA

(NASA-Case-LEW-12389-3; US-Patent-4,132,069;

US-Patent-Appl-SN-753452; US-Patent-Class-60-226R;

US-Patent-Class-60-226A; US-Patent-Class-60-39.31; US-Patent-Class-244-54; US-Patent-Class-137-15.1;

US-Patent-Class-415-201; US-Patent-Class-415-200;

US-Patent-Appl-SN-552108) Avail: US Patent and Trademark Office CSCL 21E

A nacelle for use with a gas turbine engine is provided with an integral webbed structure resembling a spoked wheel for rigidly interconnecting the nacelle and engine. The nacelle is entirely supported in its spacial relationship with the engine by means of the webbed structure. The inner surface of the nacelle defines the outer limits of the engine motive fluid flow annulus, while the outer surface of the nacelle defines a streamlined envelope for the engine.

Official Gazette of the U.S. Patent and Trademark Office

N79-14097° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

VARIABLE AREA EXHAUST NOZZLE Patent

Everett A. Johnston, inventor (to NASA) (GE, Cincinnati) Issued 2 Jan. 1979 8 p Filed 30 Apr. 1975 Sponsored by NASA (NASA-Case-LEW-12378-1: US-Patent-4,132,068;

US-Patent-Appl-SN-573029: US-Patent-Class-60-226A; US-Patent-Class-239-265.39) Avail: US Patent and Trademark Office CSCL 21E

An exhaust nozzle for a gas turbine engine comprises, a number of arcuate flaps pivotally connected to the trailing edge of a cylindrical casing which houses the engine. Seals disposed within the flaps are spring biased and extensible beyond the side edges of the flaps. The seals of adjacent flaps are maintained in sealing engagement with each other when the flaps are adjusted between positions defining minimum nozzle flow area and the cruise position. Extensible, spring biased seals, a also disposed within the flaps adjacent to a supporting pylon to thereby engage the pylon in a sealing arrangement. The flaps are hinged to the casing at the central portion of the flaps' leading edges and are connected to actuators at opposed outer portions of the leading

edges to thereby maximize the mechanical advantage in the actuation of the flaps

Official Gazette of the U.S. Patent and Trad-mark Office

N79-14098\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CERAMIC COATING EFFECT ON LINER METAL TEMPERA-TURES OF FILM-COOLED ANNULAR COMBUSTOR Russell W. Claus, Jerrold D. Wear, and Curt H. Liebert Jan. 1979 24 p refs

(NASA-TP-1323: E-9732) Avail: NTIS HC A03/MF A01 CSCL 21E

An experimental and analytical investigation was conducted to determine the effect of a ceramic coating on the average metal temperatures of full annular, film cooled combustion chamber liner. The investigation was conducted at pressures from 0.50 to 0.062. At all test conditions, experimental results indicate that application of a ceramic coating will result in significantly lower wall temperatures. In a simplified heat transfer analysis, agreement between experimental and calculated liner temperatures was achieved. Simulated spalling of a small portion of the ceramic coating resulted in only small increases in liner temperature because of the thermal conduction of heat from the hotter, uncoated liner metal.

N79-14098\* National Aeronautics and Space Administration. Lewis Research Conter, Cleveland, Ohio.

EFFECT OF SWIRLER-MOUNTED MIXING VENTURI ON EMISSIONS OF FLAME-TUBE COMBUSTOR USING JET A FUEL

David B. Ercogovic Jan. 1979 23 p refs

(NASA-TP-1393; AVRADCOM-TR-78-41; E-9762) Avail: NTIS

HC A02/MF A01 CSCL 21E

Six headplate modules in a flame-tube combustor were evaluated. Unburned hydrocarbons, carbon monoxide, and oxides of nitrogen were measured for three types of fuel injectors both with and without a mixing venturi. Tests were conducted using jet A fuel at an inlet pressure of 0.69 megapascal, an inlet temperature of 478 K, and an isothermal static pressura drop of 3 percent. Oxides of nitrogen were reduced by over 50 percent with a mixing venturi with no performance penalties in either other gaseous emissions or pressure drop. GG

N79-15046°# Boeing Military Airplane Development, Seattle,

A METHOD TO ESTIMATE WEIGHT AND DIMENSIONS OF LARGE AND SMALL GAS TURBINE FNGINES **Final Report** 

E. Onat and G. W. Klees Jan. 1979 136 p refs (Contract NAS3-21205)

(NASA-CR-159481) Avail NTIS HC A07/MF A01 CSCL 21E

A computerized method was developed to estimate weight and envelope dimensions of large and small gas turbine engines within + or - 5% to 10%. The method is based on correlations of component weight and design features of 29 data base engines. Rotating components we're estimated by a preliminary design procedure which is sensitive to blade geometry, operating conditions, material properties, shart speed, hub tip ratio, etc. The development and justification of the method selected, and the various methods of analysis are discussed

N79-15047°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOW-EMISSIONS THE ADVANCED CATALYTIC-COMBUSTER PROGRAM. PHASE 1: DESCRIPTION AND STATUS

Andrew J. Szaniszlo 1979 13 p refs To be presented at the 24th Ann. Intern. Gas Turbine Conf. and 1st Solar Energy Conf., San Diego. Calif., 11-15 Mar. 1979; sponsored by the Am. Soc. of Mech. Engr.

(NASA-TM-79049; E-9853) Avail: NTIS HC A02/MF A01 CSCL 21F

An overview of the ongoing program is presented. Objectives. plan, schedule, pollution and performance goals, catalyst advantages, present problems, and the present status of identified combustor concepts are discussed. The possible increase in upper atmosphere oxides of nitrogen (NOx) levels due to aircraft number density increases was predicted to adversely decrease ozone concentration levels. A technique for achieving low NOx emission levels was experimentally demonstrated with a lean, premixing prevaporizing flame-tube combustor.

N79-15048\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASA THERMAL BARRIER COATINGS: SUMMARY AND UPDATE

Francis S. Stepka 1978 23 p refs Presented at Proj. SQUID (ONR) Workshop on Cooling Problems in Aircraft Gas Turbines, Monterey, Calif., 27-28 Sep. 1978; sponsored by AFOSR, Naval Air Systems Command, and ONR

(NASA-TM-79053; E-9862) Avail: NTIS HC A02/MF A01 CSCL 21E

A durable, two-layer, plasma-sprayed coating consisting of a ceramic layer over a metallic layer was developed that has the potential of insulating not engine parts and thereby reducing metal temperatures and coolent flow requirements and/or permitting use of less costly and complex cooling configurations and materials. The results are summarized of analytical and experimental investigations of the coatings on flat metal specimens, turbine vanes and blades, and combustor liners. Discussed are results of investigations to detarmine coating adherence and durability, coating thermal, strength and fatigue properties, and chemical reactions of the coating with oxides and sulfates. Also presented are the effect of the coating on aerodynamic performance of a turbine vane, measured vane and cor bustor liner temperatures with and without the coating, and predicted turbine metal temperatures and coolant flow reductions potentially possible with the coating. Included also are summaries of some current research related to the coating and potential applications for the coating. Author

N79-15049\* National Aeronautics and Space Adr inistration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF FORWARD VELOCITY AND CROSSWIND ON THE REVERSE-THRUST PERFORMANCE OF A VARIABLE-PITCH FAN ENGINE

D. C. Reemsnyder and D. A. Sagerser 17 Jan. 1979 21 p. refs Presented at the 17th Aerospace Sci. Meeting, New Orleans, 15-17 Jan. 1979; sponsored by Am. Inst. of Aeron. and Astronautics

(NASA-TM-79059: E-9873: AIAA-79-0105) Avail: NTIS HC A02/MF A01 CSCL 21E

A full-size variable-pitch fan engine was tested in the Ames 40 by 80 foot wind tunnel to determine the affect of forward velocity and crosswind on reverse-thrust performance. Two flight-type inlet configurations were tested, and a flared fan nezzle was installed as an inlet for reverse-thrust operation. Steady-state reverse-thrust performance was obtained up to 54 m/s (105 knots). An abrupt decrease in reverse thrust occurred at about 30 m/s (60 knots). Reverse thrust was established following forward-to-reverse thrust \* ansients both statically and with forward velocities only up to 30 m/s.

N79-15050°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE NASA HIGH PRESSURE FACILITY AND TURBIRE TEST RIG

Francis S. Stepka 1978 17 p refs Presented at the Project SQUID (ONR) Workshop on Cooling Probl. in Aircraft Gas Turbines. Monterey, Calif., 27-28 September 1978; sponsored by AFOSR, Naval Air Systems Command, and ONR

(NASA-TM-79054: E-9863) Avail: NTIS HC A02/MF A01 CSCL 21E

A description of the facility and turbine test rig is presented. Also discussed is the turbine cooling test program.

1379-15061\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PRELIMINARY QCGAT PROGRAM TEST RESULTS

R. W. Koenig and G. K. Sievers 1979 19 p refs To be presented at the Business Aircraft Meeting, Wichita, Kas., 3-6 Apr. 1979; sponsored by SAE (NASA-TM-79013; E-9802) Avail: NTIS HC A02/MF A01

CSCL 21E

NASA Lewis Research Center is conducting a program to demonstrate that large commercial engine technology can be applied to general aviation engines to reduce noise, emissions and fuel consumption and to develop new technology where required. The overall engine program, design, and technology incorporated into the QCGAT engines are described. In addition, preliminary engine test results are presented and compared to the technical requirements the engines were designed to meet.

S.E.S

N79-15062\*# Teledyne Continental Motors, Mobile, Ala.
COMPUTER SIMULATION OF AN AIRCRAFT ENGINE FUEL
INJECTION SYSTEM Firal Report

David D. Hester Jun. 1978 93 p refs (Contracts NAS3-19755; DOT-FA74NA-1091)

(NASA-CR-157641; AD-A060452; FAA-NA-78-156; FAA-RD-78-67) Avail: NTIS HC A05/MF A01 CSCL 21/7

An analytical model of the Teledyne Continental fuel system was studied to provide a basis for quantitatively exploring deficiencies in the system response which lead to poor exhaust emission characteristics. A computer model of the fuel system was developed tased on component testing and found to give accurate predictions in pressures and flow rates within the system. The model was used to investigate modifications to the system for improved fuel management and reduced exhaust emissions. The effect of improved fuel management on engine exhaust emissions is evaluated.

N79-15957\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MEASURED AND PREDICTED NOISE OF THE AVCO-LYCOMING YF 102 TURBOFAN NOISE

Bruce J. Clark, Jack G. McArdle, and Leonard Homyak. 1979.
18 p. refs. Presented at 5th Aeroacoustics Conf., Seattle,
12-14 Mar. 1979, sponsored by AIAA.

(NASA-TM-79069, E-9885, AIAA-Paper-79-0641) Avail: NTIS HC A02/MF A01

Acoustic testing of the AVCO-Lycoming YF-102 turbofan engine was done on a static test stand in support of the quiet shorthaul research aircraft acoustic design. Overall noise levels were dominated by the fan noise emanating from the exhaust duct, except at high power settings when combination tones were generated in the fan inlet. Component noise levels, calculated by noise prediction methods were in reasonable agreement with the measured results. Far-field microphones placed at ground lavel were found superior to those at engine centerline height, even at high frequencies.

J.A.M.

N79-15958\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE GATE STUDIES: ASSESSING THE POTENTIAL OF FUTURE SMALL GENERAL AVIATION TURBINE ENGINES William C. Strack 1979 24 p rafs Presented at the Intern Ann. Gas Turbine Conf., San Diego, Calif., 11-15 Mar., 1979, sponsored by Am. Soc. of Mechanical Engineers

(NASA-TM-79075; E-9892) Avail NTIS HC A02/MF A01 CSCL 21E

Four studies were completed that explore the opportunities for future General Aviation turbine engines (GATE) in the 150-1000 SHP class. These studies forecasted the potential impact of advanced technology turbine engines in the post-1988 market, identified important aircraft and missions, desirable engine sizes, engine performance, and cost goals. Parametric evaluations of various engine cycles, configurations, design features, and advanced technology elements defined baseline conceptual engines for each of the important missions identified by the

market analysis. Both fixed-wing and helicopter aircraft, and turboshaft, turboprop, and turbofan engines were considered. Sizable performance gains (e.g., 20% SFC decrease), and large engine cost reductions of sufficient magnitude to challenge the reciprocating engine in the 300-500 SHP class were predicted.

N79-15959\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

APPLICATIONS OF VELOCITY POTENTIAL FUNCTION TO ACOUSTIC DUCT PROPAGATION AND RADIATION FROM INLETS USING FINITE ELEMENT THEORY

K. J. Baumeister and R. K. Majjigi (GE Co., Cincinnati, Ohio) 1979 12 p refs Presented at the 5th Aeroacoustics Conf. Seattle, Wash., 12-14 Mar. 1979; sponsored by AIAA (NASA-TM-79071; E-9888) Avail: NTIS HC A02/MF A01 CSCL 21E

A finite element velocity potential program was developed to study acoustic wave propagation in complex geometries. For irrotational flows, relatively low sound frequencies, and plane wave input, the finite element solutions showed significant effects of inlet curvature and flow gradients on the attenuation of a given acoustic liner in a realistic variable area turbofan inlet. The velocity potential approach can not be used to estimate the effects of rotational flow on acoustic propagation, since the potential acoustic disturbances propagate at the speed of the media in sheared flow. Approaches are discussed that are being considered for extending the finite element solution to include the far field, as well as the internal portion of the duct. A new matrix partitioning approach is presented that can be incorporated in previously developed programs to allow the finite element calculation to be marched into the far field. The partitioning approach provided a large reduction in computer storage and running times.

N79-15960\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF RADIATION PATTERNS OF INTERACTION TONES GENERATED BY INLET RODS IN THE JT15D ENGINE

M. F. Heidmann and A. V. Saule 1979 27 p refs Presented at the 5th Aeroacoustics Conf., Seattle, 12-14 Mar. 1978; sponsored by AIAA

(NASA-TM-79074; E-9891) Avail NTIS HC A03/MF A01 CSCL 21E

Interaction tones were intentionally generated by circumferential arrays of equally spaced rods that protrude radially from the inlet wall near the face of the 28-blade fan. Arrays of 28 and 41 rods, selected to give specific far field radiation properties, were tested. The expected properties were readily apparent in the measured radiation patterns. A more detailed analysis of the test data showed both the precision and limitations of the applied acoustic theory. Rods protruding 23 percent of the radius predominantly generated only lowest radial order modes, as expected. Measured and predicted radiation patterns were generally in good agreement. The agreement, however, depended on a significant degree of implied refraction due to inlet velocity gradients. Refraction, if present, would impact static-flight noise comparisons.

N79-15961\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE ROTARY COMBUSTION ENGINE: A CANDIDATE FOR GENERAL AVIATION

1978 190 p refs Symp. held at Cleveland, Ohio, 28 Feb.

(NASA-CP-2067, E-9800) Avail. NTIS HC A09/MF A01 CSCL 21A

The state of development of the rotary combustion engine is discussed. The nonturbine engine research programs for general aviation and future requirements for general aviation powerplants are emphasized. For individual titles, see: N79-15962 through N79-15968.

N79-15969\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

EVALUATION OF TWO INFLOW CONTROL DEVICES FOR FLIGHT SIMULATION OF FAN NOISE USING A JT15D ENGINE

W. L. Jones, J. G. McArdle, and L. Homyak. 1979. 17 p. refs. Presented at 5th Aeroacoustics Conf., Seattle, Washington, 12-14. Mar. 1978; sponsored by AIAA.

(NASA-TM-79072: E-9889) Avail: NTIS HC A02/MF A01 CSCL 21E

The program was developed to accurately simulate flight fan noise on ground static test stands. The results generally indicated that both the induct and external ICD's were effective in reducing the inflow turbulence and the fan blade passing frequency tone generated by the turbulence. The external ICD was essentially transparent to the propagating fan tone but the influct ICD caused attenuation under most conditions. Author

N79-16849° ₩ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NEW OPPORTUNITIES FOR FUTURE SMALL CIVIL TURBINE ENGINES: OVERVIEWING THE GATE STUDIES William C. Strack 1979 36 p Proposed for presentation at the Business and Aircraft Meeting, Wichita, Kans., 3-6 Apr. 1979; sponsored by Soc. of Automotive Engineers, Inc.

(NASA-TM-79073; E-9890) Avail: NTIS HC A03/MF A01 CSCL 21E

An overview of four independent studies forecasts the potential impact of advanced technology turbine engines in the post 1988 market, identifies important aircraft and missions, desirable engine sizes, engine performance, and cost goals. Parametric evaluations of various engine cycles, configurations, design features, and advanced technology elements defined baseline conceptual engines for each of the important missions identified by the market analysis. Both fixed-wing and helicopter aircraft, and turboshaft, turboprop, and turbofan engines were considered. Sizable performance gains (e.g., 20% SFC decrease), and large engine cost reductions of sufficient magnitude are predicted to challenge the reciprocating engine in the 300-500 SHP class.

N79-16852\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF CASING TREATMENT ON PERFORMANCE OF A TWO-STAGE HIGH-PRESSURE-RATIO FAN

Donald C. Urasek Feb. 1979 68 p refs (NASA-TP-1409; E-8997) Avail: NTIS HC A04/MF A01 CSCL

A two-stage fan, previously tested with a solid casing, was tested with a casing with circumferential grooves over the tips of both rotors (casing treatment). Tests were conducted at 80 and 100 percent of design speed with uniform flow. The casing treatment improved the flow range and stall margin significantly without changing the characteristics overall performance curves of total-pressure and efficiency as functions of weight flow, other than extending them to lower weight flows. Author

N79-17859\*# National Aeronautics and Space Administration. Lewis Research Center Cleveland, Ohio.

COLD-AIR PEGGOMMANCE OF FREE POWER TURBINE DESIGNED FOR 112-KILOWATT AUTOMOTIVE GASTURBINE ENGINE. 2: EFFECTS OF VARIABLE STATORVANE-CHORD SETTING ANGLE ON TURBINE PERFORMANCE Final Report

Kerry L McLallin and Milton G Kofskey Feb 1979 53 p

(Contract EC-77-A-31-1011)

(NASA-TM-78993, DOE/NASA/1011-78/28, E-9775) Avail. NTIS HC A04/MF A01 CSCL 21A

The cold-air performance of an axial-flow power turbine with a variable stator designed for a 112-kW automotive gas-turbine engine was determined at speeds from 30 to 110 percent of design and at pressure ratios from 1.11 to 2.67. Performance is presented in terms of equivalent mass flow, torque, power.

and efficiency for stator-vane-chord setting angles of 26 degs, 30 degs, 35 degs (design), 40 degs, 45 degs, and 50 degs. Turbine braking performance at a nominal stator setting angle of 107 degs is also presented. Turbine efficiency increased with increasing stator setting angle. A 10-point efficiency increase was obtained by opening the stator from the design setting angle of 35 degs to a setting angle of 45 degs.

Author

N79-20114\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PARAMETRIC PERFORMANCE OF A TURBOJET ENGINE
COMBUSTOR USING JET A AND A DIESEL FUEL
Helmuth F. Butze and Francis M. Humenik Mar. 1979 44 p
refs.

(NASA-TM-79089; E-9913) Avail: NTIS HC A03/MF A01 CSCL 21E

The performance of a single-can JT8D combustor was evaluated with Jet A and a high-aromatic diesel fuel over a parametric range of combustor-inlet conditions. Performance parameters investigated wera combustion efficiency, emissions of CO, unburned hydrocarbons, and NOx, as well as liner temperatures and smoke. At all conditions the use of diesel fuel instead of Jet A resulted in increases in smoke numbers and liner temperatures; gaseous emissions, on the other hand, did not differ significantly between the two fuels.

N79-20118\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TESTS OF NASA CERAMIC THERMAL BARRIER COATING FOR GAS-TURBINE ENGINES

Curt H. Liebert 1979 10 p refs Presented at the Intern. Conf. on Met. Coatings. San Diego, Calif., 23-27 Apr. 1979 (NASA-TM-79116; E-9846-1) Avail: NTIS HC A02/MF A01 CSCL 21E

A two-layer thermal barrier coating system with a bond coating of nickel-chromium-aluminum-yttrium and a ceramic coating of yttria-stabilized zirconia was tested for corrosion protection, thermal protection and durability. Full-scale gas-turbine engine tests demonstrated that this coating eliminated burning, melting, and warping of uncoated parts. During cyclic corrosion resistance tests made in marine diesel fuel products of combustion in a burner rig, the ceramic cracked on some specimens. Metallographic examination showed no base metal deterioration.

S.E.S.

N79-22099\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF A VORTEX-CONTROLLED DIFFUSER IN AN ANNULAR SWIRL-CAN COMBUSTOR AT INLET MACH NUMBERS UP TO 0.53

John M. Smith Washington Apr. 1979 17 p refs (NASA-TP-1452; E-9832) Avail: NTIS HC A02/MF A01 CSCL 21F

A short, annular dump diffuser with suction stabilized vortices in the region of abrupt area change was tested with a full scale, annular swirl can combustor. The prediffuser area ratio was 1.4. Performance data were obtained for both isothermal and burning conditions at inlet temperatures of 589 to 895 K and pressures of 0.5 to 1.0 MPa for a range of diffuser inlet Mach numbers from 0.25 to 0.53. Suction rates were 0 to 20 percent of the total diffuser mass flow rate. Diffuser effectiveness increased from 47 percent without suction to approximately 80 percent for a total suction rate of 14 percent. Combustor total pressure loss for the same total suction rate was reduced from 6.8 percent without suction to 4.0 percent at an inlet Mach number of 0.40.

N79-23086° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF PRIMARY-ZONE EQUIVALENCE RATIO ON POLLUTANT FORMATION

Russell W. Claus May 1979 20 p refs

(NASA-TP-1463; E-9896) Avail: NTIS HC A02/MF A01 CSCL 21E

Test were conducted to determine the effect of primaryzone equivalence ratio on the formation of smoke and other gaseous pollutants in an experimental can combustor. Several fuel injection techniques were examined at primary-zone equivalence ratios from 0.8 to 2.0. The main emphasis was on reducing fuel-rich-combustion smoke levels. Two of the four fuel injection configurations studied produced smoke levels below a smoke number of 20 at a primary-zone equivalence ratio of about 1.7. As the fuel mixing and atomization were recorded at primary-zone equivalence ratios as high as 2.0. The gaseous emissions of unburned hydrocarbons, carbon monoxide, and oxides of nitrogen were quite sensitive to the fuel injection configuration as well as to the primary-zone equivalence ratio.

Autior

N79-23963°# National Aeronautics and Space Administration.

COMBINED PRESSURE AND TEMPERATURE DISTORTION EFFECTS ON INTERNAL FLOW OF A TURBOFAN ENGINE W. M. Braithwaite and Ronald H. Soeder 1979 19 p refs Presented at the 15th Joint Propulsion Conf., Las Vegas, 18-20 Jun. 1979; cosponsored by AIAA, the Soc. of Automotive Engr., and ASME

(NASA-TM-79136; E-9984) Avail: NTIS HC A02/MF A01 CSCL 21E

An additional data base for improving and verifying a computer simulation developed by an engine manufacturer was obtained The multisegment parallel compressor simulation was designed to predict the effects of steady-state circumferential inlet total-pressure and total-temperature distortions on the flows into and through a turbofan compression system. It also predicts the degree of distortion that will result in surge of the compressor. The effect of combined 180 deg square-wave distortion patterns of total pressure and total temperature in various relative positions is reported. The observed effects of the combined distortion on a unitary bypass ratio turbofan engine are presented in terms of total and static pressure profiles and total temperature profiles at stations ahead of the inlet guide vanes as well as through the fan-compressor system. These observed profiles are compared with those predicted by the complex multisegment model The effects of relative position of the two components comprising the combined distortion on the degree resulting in surge are discussed. Certain relative positions required less combined distortion than either a temperature or pressure distortion by

N79-23964\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LEAN, PREMIXED, PREVAPORIZED COMBUSTION FOR AIRCRAFT GAS TURBINE ENGINES

Edward J. Mularz 1979 18 p reb. Presented at the 15th Propulsion Conf., Las Vegas. 18-20 Jun. 1979, cosponsored by AIAA, the Soc of Automotive Eng., and ASME Prepared in cooperation with Army Aviation Res. and Develop Command, St. Louis, Mo.

(NASA-TM-79148, E-004, AVRADCOM TR-79-18) Avail NTIS HC A02/MF A01 CSC 21E

The application of lean, premixed, prevaporized combustion to aircraft turbine engine systems can result in benefits in terms of superior combustion performanace, improved combustor and turbine durability, and environmentally acceptable poliutant emissions. Lean, premixed prevaporized combustion is particularly attractive for reducing the oxides of nitrogen emissions during high altitude cruise. The NASA stratospheric cruise emission reduction program will evolve and demonstrate lean, premixed, prevaporized combustion technology for aircraft engines. This multiphased program is described in addition, the various elements of the fundamental studies phase of the program are reviewed, and results to date of many of these studies are summanized.

Author

N79-23965° № National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF DEGREE OF FUEL VAPORIZATION UPON EMISSIONS FOR A PREMIXED PREVAPORIZED COMBUSTION SYSTEM

L.P. Cooper 1979 17 p. refs. Presented at the 15th Joint Propulsion Conf. Las Vegas, 18-20 Jun. 1979; cosponsored by AIAA, SAE and ASME

(NASA-TM-79154; E-010) Avail: NTIS HC A02/MF A01 CSCL

An experimental and analytical study of the combustion of partially vaporized fuelair mixtures was performed to assess the impact of the degree of fuel vaporization upon emissions for a premixing-prevaporizing flametube combusior. Data collected show near linear increases in nitrogen oxide emissions with decreasing vaporization at equivalence ratios of 0.6. For equivalence ratio of 0.72, the degree of vaporization had very little impact on nitrogen oxide emissions. A simple mechanism which accounts for the combustion of liquid droplets in partially vaporized mixtures was found to agree with the measured results with fair accuracy with respect to both trends and magnitudes.

Author

N79-23966\* "National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF SHOCKS ON FILM COOLING OF A FULL SCALE TURBOJET EXHAUST NOZZLE HAVING AN EXTERNAL EXPANSION SURFACE

David M. Straight 1979 20 p refs Presented at the 15th Joint Propulsion Conf., Las Vegas, 18-20 Jun. 1979; cosponsored by AIAA, SAE, and ASME

(NASA-TM-79157; E-013) Avail: NTIS HC A02/MF A01 CSCL 21E

Experimental film cooling data obtained during exploratory testing with an axisymmetric plug nozzle having external expansion and installed on an afterburning turbojet engine in an altitude test facility is presented. The shocks and local hot gas stream conditions had a marked effect on film cooling effectiveness. An existing film cooling correlation was adequate at some operating conditions but inadequate at other conditions such as in separated flow regions resulting from shock boundary layer interactions.

R.E.S.

N79-23967\*# National Aeronautics and Space Administration. Lewis Research Ceriter, Cleveland, Ohio.

PERFORMANCE OF TWO-STAGE FAN WITH LARGER DAMPERS ON FIRST-STAGE ROTOR

Donald C. Urasck, Walter S. Cunnan, and William Stevans. May 1979. 81 p. refs.

(NASA-TP-1399; E-8958) Avail: NTIS HC A05/MF A01 CSCL 21E

The performance of a two stage, high pressure-ratio fan, having large, part-span vibration dampers on the first stage rotor is presented and compared with an identical aerodynamically designed fan having smaller dampers. Comparisons of the data for the two damper configurations show that with increased damper size (1) very high losses in the damper region reduced overall efficiency of first stage rotor by approximately 3 points, (2) the overall performance of each blade row, downstream of the damper was not significantly altered, although appreciable differences in the radial distributions of various performance performance of the first stage rotor decreased the overall fan efficiency more than 1 percentage point.

NT9-23968\* Mational Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF STEADY-STATE PRESSURE DISTORTION ON THE STALL MARGIN OF A J85-21 TURBOJET ENGINE George A. Bobula Mar. 1979—28 p. refs. Prepared in cooperation with Army Aviation Research and Development Command. Cleveland, St. Louis, Mo.

(NASA-TM-79123, E-9958, AVRADCOM-TR-79-12) Avail: NTIS HC A03/MF A01 CSCL 21E

The effects of the inlet pressure distortions, induced by five screen patterns, on the performance of a J85-21 turbojet engine was conducted at the NASA Lewis Research Center Testing was in support of the HIMAT RPRV program at Dryden Flight Research Center Distortion patterns were chosen based on auticipated application of test results of the HIMAT installation

Tests were conducted at a simulated Mach number and altitude condition of 0.9 and 10 973 meters. Results are presented in terms of distortion levels and standard compressor performance parameters.

Author

N79-23969\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF STEADY-STATE PRESSURE DISTORTION ON FLOW CHARACTERISTICS ENTERING A TURBOFAK ENGINE

Ronald H. Soeder and George A. Bobula Apr. 1979 34 p refs Prepared in cooperation with Army Aviation Research and Development Command, St. Louis, Mo. (NASA-TM-79134; E-9982; AVRADCOM-TR-79-19) Avail.

NTIS HC A03/MF A01 CSCL 21E

Flow angle, static-pressure, and total-pressure distributions were measured in the passage ahead of a turbofan engine operating with inlet pressure distortion. Distortions were generated with five screen configurations and one solid plate configuration. The screens and solid plate were circumferential and mounted on a rotatable assembly. Reynolds Number Index upstream of the distortion device was maintained at 0.5, 0.35, or 0.2, and engine corrected low rotor speeds were held at 6000 rpm and 8600 rpm. Near the engine inlet, flow angle was largest at the hub and increased as flow approached the engine. The magnitude of static-pressure distortion measured along the inlet-duct and extended buillet nose walls increased exponentially as the flow approached the engine. Wall static-pressure distortion was also a function of distortion harmonic.

Author

N79-24994°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PREMIXED PREVAPORIZED COMBUSTOR TECHNOLOGY FORUM

1979 262 p refs Conf. held at Cleveland, Ohio, 9-10 Jan. 1979

(NASA-CP-2078; E-9933) Avail NTIS HC A12/MF A01 CSCL

The Forum was held to present the results of recent and current work intended to provide basic information required for demonstration of lean, premixed prevaporized combustors for aircraft gas turbine engine application Papers are presented which deal with the following major topics (1) engine interfaces (2) fuel-air preparation, (3) autoignition; (4) lean combustion, and (5) concept design studies. For individual titles, see N79-24995 through N79-25014.

N79-24995\* Pratt and Whitney Aircraft Group, East Hartford,

TURBULENCE CHARACTERISTICS OF COMPRESSOR DISCHARGE FLOWS

Howard P Grant In NASA Lewis Res Center Premixed Prevaporized Combustor Technol Forum 1979 p 5-31 (For primary document see N79-24994 16-07) Avail NTIS HC A12/MF A01 CSCL 21E

Turbulence measurements were conducted in a large gas turbine engine (JT9D) at the entrance to the diffuser duct, joining the compressor discharge to the combustor inlet. Hot film probe and hot wire probe measurements were obtained at temperatures from 450K (350F) (idle) to 608K (635F) (rich approach). At I.D. (25 percent span) and mid-span locations, the turbulence intensity increased slightly from 6 + 3r - percent at idle condition to 7 or - 1 percent at rich approach. At O.D. (75 percent span) the turbulent intensity increased more rapidly, from 7.5 + or - 0.5 percent at idle to 15 + or - 0.5 percent at rich approach. The spectra showed turbulent energy distributed uniformly over a 0.1 to 5. KHz bandwidth (down 3db) at all operating conditions corresponding to random turbulence with velocity wave lengths of 2 cm to 1 meter travelling at the mean velocity of 100 m/sec. Tests results are given in tables and graphs.

N79-24996\* General Electric Co., Cincinnati, Ohio.
TURBULENCE MEASUREMENTS IN THE COMPRESSOR
EXIT FLOW OF A GENERAL ELECTRIC CF6-50 ENGINE
Jack R. Taylor In NASA. Lewis Res. Center Premixed
Prevaporized Combustor Technul Forum 1979 p 33-45 (For primary document see N79-24994 16-07)
Avail NTIS HC A12/MF A01 CSCL 21E

Ruggedized cooled film probes were used to measure CF6-50 compressor exit turbulence properties at three different engine idle condition test points. The turbulence probe was coupled to a constant temperature anemometer and signal conditioning system. An on-line readout system connected to the anemometer was used to check the data as it was acquired. At engine idle conditions, the turbulence intensity ranged from 4.8 percent to 5.6 percent and the length scale ranged from 5.64 cm to 6 95 cm. The length scale values are somewhat larger than the passage height at the measurement plane (5.54 cm), which indicates that the shape of the turbulent eddies are elongated in the axial direction. The microscale values range from about 0.73 cm to about 0.98 cm. Power spectral density distributions show that a large proportion of the turbulent energy at the measurement plane is concentrated at frequencies below one kilohertz

N79-24997\*# Solar Turbines International, San Diego, Calif. FUEL SPRAY DATA WITH LDV

David A. Rohy and John G. Meier In NASA. Lewis Res. Center Premixed Prevaporized Combustor Technol. Forum 1979 p. 47-55 (For primary document see N79-24994 16-07) Avail: NTIS HC A12/MF A01 CSCL 21E

Droplet size and two component velocities in the severe environment of an operating gas turbine combustor system can be measured simultaneously using the solar laser morphokinetomer (SLM) which incorporates the following capabilities: (1) measurement of a true two-dimensional velocity vector with a range of + or - (0.01-200 m/sec); (2) measurement of particle size (range 5 to 300 micron m) simultaneously with the measurement of velocity; (3) specification of probe volume position coordinates with a high degree of accuracy (+ or - 0.5 mm); (4) immediate on-line data checks; and (5) rapid computer storage of acquired data. The optical system of the SLM incorporates an ultrasonic beam splitter to allow the measurement of a two-dimensional velocity vector simultaneously with particle size. A microprocessor with a limited storage capability permits immediate analysis of test data in the test cell.

A.R.H.

 $\mbox{N79-24998}\mbox{\ensuremath{\#}}\mbox{\ensuremath{\#}}\mbox{\ensuremath{United}}\mbox{\ensuremath{Technologies}}\mbox{\ensuremath{Research}}\mbox{\ensuremath{Research}}\mbox{\ensuremath{Center}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{Research}}\mbox{\ensuremath{Research}}\mbox{\ensuremath{Center}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{Research}}\mbox{\ensuremath{Research}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbox{\ensuremath{East}}\mbo$ 

MODELING OF PREMIXING-PREVAPORIZING FUEL-AIR MIXING PASSAGES

O. L.-Inderson, J. B. McVey, D. E. Edwards, and L. M. Chiappetta In NASA. Lewis Res. Center. Premixed Prevaporized Combustor Technol. Forum. 1979. p. 57-65 (For primary document see N79-24994. 16-07)

Avail NTIS HC A12/MF A01 CSCL 21E

The development of a computer program for the analytical prediction of the distribution of liquid and vapor fuel in the premixing-prevaporizing passage by the direct injection method is described. The technical approach adopted for this program is to separate the problem into three parts each with its own computer code. These three parts are: calculation of the two-dimensional or axisymmetric air flow, calculation of the two-dimensional fuel droplet evaporation, and calculation of the fuel vapor diffusion. This method of approach is justified because plemixing passages operate at lean equivalence ratios. Hence, a weak interaction assumption can be made wherein the airflow can affect the fuel droplet behavior but the fuel droplet behavior does not affect the airflow.

A.R.H.

N79-24999\*# Michigan Univ., Ann Arbor.

EFFECT OF FUEL SPRAYS ON EMISSIONS

J. A. Nicholls In NASA. Lewis Res. Center Premixed Prevaporized Combustor Technol. Forum 1979 p 67-84 refs (For primary document see N79-24994 16-07) (Grant NsG-3148)

Avail: NTIS HC A12/MF A01 CSCL 21E

A research gas turbine combustor was operated under realistic conditions such that the influence of individual variables (in particular, fuel spray characteristics) on emissions could be determined. The special combustor allows independent control over drop size, fuel-air ratio, air inlet temperature, pressure, reference velocity, and residence time. Also, it lends itself to theoretical modeling and turbulent intensity measurements through use of laser velocimetry. Emission results for a range of operations are presented. A number of graphs show which show the variations of emissions levels with one variable at a time are included. In every case, the fuel is jet A, the pressure is atmospheric, and combustion is limited to a primary zone.A.R.H.

N79-25000\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF A MULTIPLE VENTURI FUEL-AIR PREPARATION SYSTEM

Robert R. Tacina In its Premixed Prevaporized Combustor Technol. Forum 1979 p 85-93 refs (For primary document see N79-24994 16-07)

Avail: NTIS HC A12/MF A01 CSCL 21E

Spatial fuel-air distributions, degree of vaporization, and pressure drop were measured 16.5 cm downstream of the fuel injection plane of a multiple Venturi tube fuel injector. Tests were performed in a 12 cm tubular duct. Test conditions were: a pressure of 0.3 MPa, inlet air temperature from 400 to 800K, air velocities of 10 and 20 m/s, and fuel-air ratios of 0.010 and 0.020 The fuel was Diesel #2. Spatial fuel-air distributions were within + or - 20 percent of the mean at inlet air temperatures above 450K. At an inlet air temperature of 400K the fuel-air distribution was measured when a 50 percent blockage plate was placed 9.2 cm upstream of the fuel injection plane to distort the inlet air velocity fuel injection plane to distort the inlet air velocity profile Vaporization of the fuel was 50 percent complete at an inlet air temperature of 400K and the percentage increased linearly with temperature to complete vaporization at 600K. The pressure drop was 3 percent at the design point which was three times greater than the designed value and the single tube experiment value. No autoignition or flashback was observed at the conditions tested.

N79-25001°# United Technologies Research Center, East Hartford, Conn.

AUTOIGNITION OF FUELS

Louis J. Spadaccini In NASA. Lewis Res Center Premixed Prevaporized Combustor Technol. Forum 1979 p 95-107 ref (For primary document see N79-24994 16-07)

Avail. NTIS HC A12/MF A01 CSCL 21E

An autoignition test section and a premixing fuel injector developed to determine the autoignition characteristics of a variety of aircraft fuels are described. Parametric tests to map the ignition delay characteristics of Jet-A fuel were conducted at pressures of 10, 15, 20, 25, and 30 atm, inlet air temperatures up to 900K and fuel-air equivalence ratios of 0.3, 0.5, 0.7, and 1.0. Residence times in the range of 1 to 50 msec were obtained by interchanging spool pieces to create six different mixer/vaporizer lengths (6, 23, 53, 84, 99, and 130 cm) and by testing at two different airflow rates (0.5 and 1.0 kg/sec). The resulting free-stream velocities were in the range 20 to 100 m/sec. As expected, the results indicate that the ignition delay times decrease with increasing air temperature and pressure. Also, the data show that, for lean mixtures, ignition delay times decrease with increasing equivalence ratios.

N79-25002\*# General Applied Science Labs., Inc., Westbury.

EMISSIONS MEASUREMENTS FOR A LEAN PREMIXED PROPANE/AIR SYSTEM AT PRESSURES UP TO 30 ATMOSPHERES

Gerald Roffe In NASA Lewis Res. Center Premixed Prevaporized Combustor Technol. Forum 1979 p 109-125 Forum 1979 p 109-125 (For primary document see N79-24994 16-07) Avail: NTIS HC A12/MF A01 CSCL 21E

A series of experiments was conducted in which the emissions of a lean premixed system of propane and air were measured at pressures of 5, 10, 20 and 30 atm in a flametube apparatus. Measurements were made for inlet temperatures between 600K and 1000K and combustor residence times from 1.0 to 3.0 msec. A schematic of the test rig is presented along with graphs showing emissions measurements for nitric oxide, carbon monoxide, and UHC as functions of bustor residence time for various equivalence ratios, entrance temperatures and pressures; typical behavior of emissions as a function of equivalence ratio for a fixed residence time. Correlations of nitric oxide emission index with adiabatic flame temperature for a fixed residence time of 2 msec and pressures from 5 to 30 atm; and adiabatic flame temperature corresponding to CO breakpoint conditions ror 2 msec residence time as a function of inlet temperature.

A.R.H.

N79-25003\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF DEGREE OF FUEL VAPORIZATION ON EMISSIONS FOR A PREMIXED-PREVAPORIZED COMBUSTOR SYSTEM

Larry P. Cooper In its P.emixed Prevaporized Combustor Technol. Forum 1979 p 127-130 (For primary document see N79-24994 16-07)

Avail: NTIS HC A12/MF A01 CSCL 21E

The impact of the degree of fuel vaporization upon emission from a flametube combustor was studied using an inlet air pressure of 3 x 10 to the 5th power pascals, inlet air temperatures of 600K and 700K, a reference velocity of 35 meters per second and equivalence ratios of .6 and .72 using Jet A fuel. Incoming air was preheated to temperatures from 600K to 700K by a nonvitiating preheater. Jet A fuel was injected into this airstream through two different fuel injectors manifolded together and mounted in series upstream of a watercooled preforated plate flameholder. The fuel-air mixture burner, in a watercooled combustor section. Samples of the fuel-air mixture upstream of the flameholder were obtained for analysis to determine the local degree of fuel vaporization and the fuel-air ratio Samples of the combustion products were analyzed to determine gaseous er... ons. The effects of vaporization on carbon monoxide and nitric carbon monoxide and nitric oxide emissions are presented. A.R.H.

N79-25004\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF FUEL/AIR NONUNIFORMITY ON NITRIC OXIDE EMISSIONS

Valerie J. Lyons In its Premixed Prevaporized Combustor Technol. Forum 1979 p 131-134 (For primary document see N79-24994

Avail NTIS HC A12/MF A01 CSCL 21E

A flame tube combustor holding jet A fuel was used in experiments performed at a pressure of 3 Mpa and a reference velocity of 25 meters/second for three inlet air temperatures of 800, 700, and 800 K. The gas sample measurements were taken at locations 18 cm and 48 cm downstream of the perforated plate flameholder. Nonuniform fuel/air profiles were produced using a fuel injector by separately fueling the inner five fuel tubes and the outer ring of twelve fuel tubes. Six fuel/air profiles were produced for nominal overall equivalence ratios of 5 and 6. An example of three of three of these profiles and their resultant nitric oxide NOx emissions are presented. The uniform fuel/air profile cases produced uniform and relatively low profile levels. When the profiles were either center-peaked or edge-peaked, the overall mass-weighted nitric oxide levels increased.

A.R.H

N79-25005°# General Applied Science Labs., Inc., Westbury.

EFFECTS OF FLAMEHOLDER GEOMETRY ON EMISSIONS AND PERFORMANCE OF LEAN PREMIXED COMBUSTORS

K. S. Venkataramani In NASA. Lewis Res. Center Premixed Prevaporized Combustor Technol. Forum 1979 p 135-155 (For primary document see N79-24994 16-07) Avail: NTIS HC A12/MF A01 CSCL 21E

Emission levels and performance of twelve flameholder designs were investigated in a lean, premixed propane-air system at inlet conditions of 800K and 10 atm. The flameholder tested represents six design concepts with two values of blockage for each concept. The design concept consists of the following geometries: perforated plate, wire grid, single cone, multiple cone, wee gutter and swirl cone. Measurements were made at reference velocities of 35 m/s, 25 m/s and 20 m/s at combustor stations 10 cm and 30 cm downstream of the flameholder, G.Y.

N79-25006\* National Aeronatics and Space Administration. Lewis Research Center, Clevela . Ohio.

EFFECTS OF FLAMEHOLDER BLOCKAGE ON EMISSIONS AND PERFORMANCE OF LEAN PREMIXED-PREVAPORIZED COMBUSTORS

Robert A. Duerr *In its* Premixed Prevaporized Combustor Technol. Forum 1979 p 157-162(For primary document see N79-24994 16-07)

Avail: NTIS HC A12/MF A01 CSCL 21E

The results from a parametric study are presented. Tests were on conducted at inlet air pressure of 300,000 and 500,000 pascals, inlet air temperatures of 600K, 700K and 800K, reference velocites from 20 to 35 meters per second, and equivalent ratios from the lean stability limit to 0.7 using Jet A fuel. The tests were conducted in a closed duct test facility. Results from the test support the theory that flameholder blockage is one of the major determinants of the size and shape of the recirculation zone. The test data show that higher blockage with its larger recirculation zone provides more residence time which leads to more NOx formation.

N79-25007\*# United Technologies Research Center, East Hartford, Conn.

LEAN STABILITY AUGMENTATION STUDY

John B. McVey and Jan B. Kennedy. In NASA. Lewis Res. Center. Premixed Prevaporized Combustor Technol. Forum. 1979 p. 163-177 (For primary document see N79-24994 16-07). Avail. NTIS. HC A12/MF A01. CSCL 21E.

An analytical and experimental program was conducted to investigate techniques and develop technology for improving the lean combustion limits of premixing, prevaporizing combustors applicable to gas turbine engine main burners. Three concents for improving lean stability limits were selected for experimental evaluation among twelve approaches considered. Concepts were selected on the basis of the stential for improving stability limits and achieving emis of goals, the technological risks associated with development of practical burners employing the concepts, and the penalties to airline direct operating costs resulting from decreased combustor performance, increased engine cost, increased maintenance cost and increased engine weight associated with implementation of the concepts. Tests of flameholders embodying the selected concepts were conducted.

N79-25008\* Massachusetts Inst. of Tech., Cambridge.
MODELLING TURBULENT FLAME IGNITION AND BLOWOUT

Krishnan Radhakrishnan and John B. Heywood. In NASA. Lewis Res. Center. Premixed Prevaporized Combustor Technol. Fcrum 1979. p. 179-186. refs. (For primary document see. N79-24994. 16-07.)

(Grant NGR-22-009-378)

Avail NTIS HC A12/MF A01 CSCL 21E

A statistical mixing model incorporating an overall rate equation to describe the fuel oxidation process was developed for studies of ignition and blowout in a combustor primary zone.

This zone is treated as a partially stirred reactor whose composition is described by a statistical ensemble of equal mass fluid elements. This ensemble experiences mixing interactions, which represent the turbulent mixing process, at time intervals governed by an empirically determined mixing frequency. Each mixing interaction is computed by ramdomly selecting two different elements which are then allowed to mix completely so that they reach a mean composition depending on their thermodynamic states prior to mixing. The two elements then separate, and the chernical kinetics proceed depending on their new composition and temperature.

G.Y.

N79-25011\*# General Electric Co., Cincinnati, Ohio.
ADVANCED LOW EMISSIONS CATALYTIC COMBUSTOR
PROGRAM /... GENERAL ELECTRIC

W. J. Dodds NASA. Lawis Res. Center Premixed Prevaporized Combustor Technol. Forum 1979 p 215-227 refs (For primary document see N79-24994 16-07)

Avail: NTIS HC A12/MF A01 CSCL 21E

The Advanced Low Emissions Catalytic Combustors Program (ALECC) is being undertaken to evaluate the feasibility of employing catalytic combustion technology in aircraft gas turbine engines as a means to control emission of oxides of nitrogen during subsonic stratospheric cruise operation. The ALECC Program is being conducted in three phases. The first phase, which was completed in November, 1978, consisted of a design study to identify catalytic combustor designs having the greatest potential to meet the emissions and performance goals specified. The primary emissions goal of this program was to obtain cruise NO emissions of less than 1g/kg (compared with levels of 15 to 20 g/x obtained with current designs)/ However, good overall performance and feasibility for engine development were heavily weighted in the evaluation of combustor designs. G.Y.

N79-25012°# Pratt and Whitney Airc. aft Group, East Haltford,

ADVANCED LOW EMISSIONS CATALYTIC COMBLETOR PROGRAM AT PRATT AND WHITNEY

G. J. Sturgess /n NASA. Lewis Res. Center Premixed Prevaporized Combustor Technol. Forum. 1979 p. 229-245 (For primary document see N79-24994 16-07) Avail: NTIS HC A12/MF A01 CSCL 21E

The feasibility of employing catalytic combustion technology to control the emissions of oxides of nitrogen for subsonic, stratospheric cruise aircraft operations is the objective of this NASA contract. The existing Enivornmental Protection Agency standards for the landing and takeoff cycle were also required to be satisfied. Work for the first phase of a proposed three phase effort is reported and is concerned with analytical design studies.

G.Y.

N79-25013\*# Pratt and Whitney Aircraft Group, East Hartford,

LEAN, PREMIXED, PREVAPORIZED COMBUSTOR CON-CEPTUAL DESIGN STUDY

Anthony J Fiorentino /n NASA. Lewis Res. Center Premixed Prevaporized Combustor Technol. Forum. 1979 p. 247-254 (For primary document see N79-24994 16-07). Avail. NTIS HC A12/MF A01 CSCL 21E

The seven month study program has the objective to identify and evaluate promising lean, premixed, prevaporized combustor concepts utilizing variable geometry and/or other flow control techniques. The general approach taken to accomplish this objective is outlined and consists of combustor design, design analysis and design ranking. The schedule being taken to achieve this program is shown. Although the ultimate goal of this program is the significant reduction of cruise oxides of nitrogen, both the EPA emission standards and combustor performance levels outlined are retained as goals as well.

G.Y.

N79-25014\*# General Electric Co., Cincinnati, Ohio, LEAN, PREMIXED, PREVAPORIZED COMBUSTOR CONCEPTUAL DESIGN STUDY

E. E. Ekstedt /n NASA. Lewis Res. Center Premixed Prevaporized Combustor Technol. Forum 1979 p 255-263 (For primary document see N79-24994 16-07)

Avail: NTIS HC A12/MF A01 CSCL 21E

Phase 1 of the Lean Premixed-Prevaporized Comubstor Design Study is a nine month analytical study effort with no experimental or testing activities included. The program has the objective to design and analyze advanced combustor concepts with features for fuel premixing and prevaporization upstream of the combustion zone for use in future subsonic aircrafts with features for fuel premixing and prevaporization upstream of the combustion zone for use in future subsonic aircraft engines. All of the designs also embody some form of variable geometry for combustor flow modulation. The primary criterion for these designs is low oxides of hitrogen emissions at stratospheric cruise conditions. Four combustor concepts are being designed for the NASA/GE Energy Efficient Engine (EEE) envelope and cycle. Current status of the program is that the four concepts sized for the EEE were designed and are currently undergoing analysis and evaluation.

G.Y

N79-25015\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MULTIVARIABLE CONTROL ALTITUDE DEMONSTRATION ON THE F100 TURBOFAN ENGINE

B. Lehtinen, R. L. DeHoff (Systems Control, Inc., Palo Alto, Calif.), and R. D. Hackney (Pratt and Whitney Aircraft Group, West Palm Beach, Fla.) 1979—31 p. refs. Presented at the 15th Joint Propulsion Conf., Las Vegas, Nev., 18-20 Jun. 1979; sponsored by AlAA, Soc. of Automotive Engr., and ASME (NASA-TM-79183; E-050) Avail. NTIS HC A03/MF A01 CSCL 21E.

The F100 Multivariable control synthesis (MVCS) program, was aimed at demonstrating the benefits of LGR synthesis theory in the design of a multivariable engine control system for operation throughout the flight envelope. The advantages of such procedures include: (1) enhanced performance from cross-coupled controls, (2) maximum use of engine variable geometry, and (3) a systematic design procedure that can be applied efficiently to new engine systems. The control system designed, under the MVCS program, for the Pratt & Whitney F100 turbofan engine is described. Basic components of the control include: (1) a reference value generator for deriving a desired equilibrium state and an approximate control vector, (2) a transition model to produce compatible reference point trajectories during gross transients. (3) gain schedules for producing feedback terms appropriate to the flight condition, and (4) integral switching logic to produce acceptable steady-state performance without engine operating limit exceedance. JAM

N79-25016° 

Mational Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio FUNDAMENTALS OF GAS TURBINE COMBUSTION

Melvin Gerstein (Univ of Southern Calif. Los Angeles) 1979 52 p Workshop held at Cleveland, 6-7 Feb. 1979 (NASA-CP-2087, E-026) Avail NTIS HC A04/MF A01

Combustion problems and research recommendations are discussed in the areas of atomization and vaporization, combustion chemistry, combustion dynamics, and combustion modelling. The recommendations considered of highest priority in these areas are presented.

N79-25022\*# National Aeronautics and Space Administration Lewis Research Center, Reveland, Ohio.

OPERATING CONDITIC A AND GEOMETRY EFFECTS ON LOW-FREQUENCY AFTERBURNER COMBUSTION INSTA-BILITY IN A TURBOFAN AT ALTITUDE

Richard R Cullom and Roy L Johnsen Jun 1979 31 p refs (NASA-TP-1475, E-9886) Avail NTIS HC A03/MF A01 CSCI 21E Throe afterburner configurations were tested in a low-bypassratio turbofan engine to determine the effect of various fuel
distributions, inlet conditions, flameholder geometry, and fuel
injection location on combustion instability. Tests were conducted
at simulated flight conditions of Mach 0.75 and 1.3 at altitudes
from 11,580 to 14,020 m (38,000 to 46,000 ft). In these tests
combustion instability with frequency from 28 to 90 Hz and
peak-to-peak pressure amplitude up to 46.5 percent of the
afterburner inlet total pressure level was encountered. Combustion instability was suppressed in these tests by varying the
fuel distribution in the afterburner.

Author

N79-25023\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## INDUSTRY TESTS OF NASA CERAMIC THERMAL BARRIER COATING

Curt H. Liebert and Francis S. Stepka Jim. 1979 26 p. refs. Presented at 6th Intern. Vacuum Metallurgy Conf., San Diego, Calif. 23-27 Apr. 1979; Sponsored by Am. Vacuum Soc. (NASA-TP-1425; E-9846) Avail: NTIS HC A03/MF A01 CSCL 21E.

Ceramic thermal barrier coating (TBC) system was tested by industrial and governmental organizations for a variety of aeronautica, marine, and ground-based gas turpine engine applications. This TBC is a two-layer system with a bond coating of nickel-cinicinium-aluminum-yttrium (Ni-16Cr-6Al-0.6Y, in wt. percent) and a ceramic coating of yttria-stabilized zirconia (ZrO2-12Y2O3, in wt. percent). Seven tests evaluated the system's thermal protection and durability. Five other tests determined thermal conductivity, vibratory fatigue characteristics, and corrosion resistance of the system. The information presented includes test results and photographs of the coated parts. Recommendations are made for improving the coating procedures.

J.M.S.

N79-27140°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TURBINE ENGINE ALTITUDE CHAMBER AND FLIGHT TESTING WITH LIQUID HYDROGEN

E. William Conrad. 1979. 22 p. refs. Presented at the Intern. DGLR/DFVLR Symp. on Hydrogen in Air Transportation, Stuttgart, 11-14 Sep. 1979.

(NASA-TM-79196; E-062) Avail: NTIS HC A02/MF A01 CSCL 21E

Flight engine experiments using liquid hydrogen fuel were reviewed. A few implications of the results to modern turbine engines are presented. A subsequent contract dealing with a positive displacement pump operating on liquid hydrogen is discussed, and some aspects of liquid hydrogen propellant systems, reflected by rocket booster experience are treated. S.E.S.

N79-27141\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ENERGY EFFICIENT AIRCRAFT ENGINES

Roger Chamberlin and Brent Miller 1979 21 p refs Presented at Aircraft Systems Meeting, New York, 20-22 Aug. 1979; sponsored by AIAA

(NASA-TM-79204, E-089) Avail NTIS HC A02/MF A01 CSCL 21E

The three engine programs that constitute the propulsion portion of NASA's Aircraft Energy Efficiency Program are described, their status indicated, and anticipated improvements in SFC discussed. The three engine programs are (1) Engine Component Improvement--directed at current engines, (2) Energy Efficiency Engine directed at new turbofan engines, and (3) Advanced Turboprops--directed at technology for advanced turboprop--powered aircraft with cruise speeds to M in 18. Unique propulsion system interactive ties to the airframination are discussed. Emphasis is placed on the advanced turboprop since it offers the largest poetnital fuel savings of the three propulsion programs and also has the strongest interactive ties to the airframe.

N79-27142\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FLOW VISUALIZATION OF DISCRETE-HOLE FILM COOL-ING WITH SPANWISE INJECTION OVER A CYLINDER Louis M. Ruscell Jul. 1975 15 p refs

(NASA-TP-1491; E-9946) Avail: NTIS HC A02/MF A01 CSCL

Insight into the fluid mechanics encountared when film air from a single row of holes is injected over a cylinder in a mainstream at conditions simula' in a film cooled, turbulent-vane leading edge was investigated. Smoke was added to the cooling air to visualize its flow path. Film was injected in the spanwise direction at angles of 30 deg and 45 deg to the surface; at angular locations of 15 deg, 30 deg, 45 deg, and 60 deg from the stagnation line; and at various blowing ratios. The observations were related to the measured heat transfer data of others. The results indicate that, in addition to the expected growth in film thickness and the greater penetration of the boundary layer with increasing blowing ration, there was an absence of spanwise spreading and only a small spanwise deflection of the injected film. SES

N79-27143\*# National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.
FERFORMANCE OF TWO-STAGE FAN HAVING LOW-

ASPECT-RATIO FIRST-STAGE ROTOR BLADING

Donald C. Urasek, William T. Gorrell (Army Aviation Res. and Develop, Command, Cleveland), and Walter S. Cunnan Aug. 1979 132 p Prepared in cooperation with US Army Aviation Research and Development Command, Cleveland

(NASA-TP-1493: AVRADCOM-TR-78-49; E-9237) Avail NTIS HC A07/MF A01 CSCL 21E

The NASA two stage fan was tested with a low aspect ratio first stage rotor having no midspan dampers. At design speed the fan achieved an adiabatic design efficiency of 0.846. and peak efficiencies for the first stage and rotor of 0.870 and 0.906, respectively Peak efficiency occurred very close to the stall line. In an attempt to improve stall margin, the fan was retested with circumferentially grooved casing treatment and with a series of stator blade resets. Results showed no improvement in stall margin with casing treatment but increased to 8 percent with stator blade reset

N79-27179°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

REVIEW OF THE AGARD S AND M PANEL EVALUATION PROGRAM OF THE NASA-LEWIS SRP APPROACH TO HIGH-TEMPERATURE LCF LIFE PREDICTION

Marvin H Hirschberg In AGARD Stresses Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 9 p :efs (For primary document see N79-27148 18-07)

Avail NTIS HC A21/MF A01 CSCL 21E

The strain range partitioning SRP method method presented is a significant step forward in high temperature low cycle fatigue life prediction. Several concerns and recommendations regarding SRP were described. These dealt primarily with the problems associated with the application of SRP to cases involving small inelastic strains (and therefore long lives). The difficulties associated with partitioning these narrow hysteresis loops and the present inability of SRP to handle mean stress effects were MMM also noted.

N79-2718: \* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SUPERSONIC UNSTALLED FLUTTER

J. J. Adamczyk, M. E. Goldstein, and M. J. Hartmann. In AGARD Stresses, Vibrations, Struct, Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 14 p refs (For primary document see N79-27148 18-07) Avail: NTIS HC A21/MF A01 CSCL 21E

A parametric study to show the effects of cascade geometry. italet Mach number, and backpressure on the onset of single

and multi degree of freedom unstalled supersonic flutter is presented. Several of the results are correlated against experimental qualitative observation to validate the models.

N79-28176\*# National Aeronautics and Space Administration. Lewis Rr earch Center, Cleveland, Ohio.

A THROAT-BYPASS STABILITY-BLEED SYSTEM USING RELIEF VALVES TO INCREASE THE TRANSIENT STABILITY OF A MIXED-COMPRESSION INLET

George H. Neiner, Miles O. Dustin, and Gary L. Cole Jul. 1979 47 p refs

(NASA-TP-1083; E-8950) Avail: NTIS HC A03/MF A01 CSCL

A stability-bleed system was installed in a YF-12 flight inlet that was subjected to internal and external airflow disturbances in the NASA Lewis 10 by 10 foot supersonic wind tunnel. The purpose of the system is to allow higher inlet performance while maintaining a substantial tolerance (without unstart) to internal and external disturbances. At Mach numbers of 2.47 and 2.76, the inlet tolerance to decreases in diffuser-exit corrected airflow was increased by approximately 10 percent of the operating-point airflow. The stability-bleed system complemented the terminalshock-control system of the inlet and did not show interaction problems. For disturbances which caused a combined decrease in Mach number and increase in angle of attack, the system with valves operative kept the inlet started 4 to 28 times longer than with the valves inoperative. Hence, the stability system provides additional time for the inlet control system to react and prevent unstart. This was observed for initial Mach numbers of 2.55 and 2.68. For slow increase in angle of attack at Mach 2.47 and 2.76, the system kept the inlet started beyond the steady-state unstart angle. However, the maximum transient angles of attack without unstart could not be determined because wind-tunnel mechanical-stop limits for angle of attack were reached.

N79-28177\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF ROTOR MERIDIONAL VELOCITY RATIO ON RESPONSE TO INLET RADIAL AND CIRCUMFERENTIAL DISTORTION

Nelson L. Sanger Jul 1979, 73 p refs (NASA-TP-1278; E-8987) Avail NTIS HC A04/MF A01 CSCL 21E

Three single transonic fan stages, each having a different meridional velocity ratio across its rotor were tested with two magnitudes of tip radial distortion and with a 90 deg circumferential distortion imposed on the inlet flow. The rotor with the lowest meridional velocity ratio (less than C9 at the tip) demonstrated the least degradation of performance due to these distortions. Loss and deviation angle data (as needed for performance prediction with radial distortion) calculated along actual streamlines for radially distorted flow and correlated against diffusion factor, showed consistent agreement with data calculated along design streamlines for undistorted flow Author

N79-30187°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

EFFECT OF STEADY-STATE TEMPERATURE DISTORTION AND COMBINED DISTORTION ON INLET FLOW TO A TURBOFAN ENGINE

Ronald H Soeder and George A Bobula Aug 1979 43 p

NASA TM-79237, E-143) Avail NTIS HC A03/MF A01 CSCL 21E

Flow angle, static pressure, total temperature and total pressure were measured in the inlet duct upstream of a turbofan engine operating with temperature distortion or combined pressure-temperature distortion. Such measurements are useful in the evaluation of analytical models of inlet distortion. A rotating gaseous-hydrogen burner and a circumferential 180 degreesextent screen configuration incunted on a rotatable assembly generated the distortions. Reynolds number index was maintained at 0.5 and engine corrected low-miss speeds were held at 6000 and 8000 rpm. The measurements showed that at the entrance to the engine, flow angle was largest in the hub region. As flow approached the er.gir. yaw angle (circumferential variation) increased and pitch angle (radial variation) decreased. The magnitude of static-pressure distortion measured along the inlet-duct and extended builet nose walls increased exponentially as flow approached the engine. Author

N79-30188°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A SUMMARY OF NASA/AIR FORCE FULL SCALE ENGINE RESEARCH PROGRAMS USING THE F100 ENGINE

V. J. Deskin (Fratt and Whitney Aircraft Group, West Palm Beach, Fla.) and H. G. Hurrell 1979 24 p refs Presented at 15th Joint Propulsion Conf., Las Vegas, Nev., 18-20 Jun. 1979; Sponsored by AIAA, Am. Soc. of Mech. Engr. (NASA-TM-79267; E-183) Avail: NTIS HC A02/MF A01 CSCL

21E

A full scale engine research (FSER) program conducted with the F100 engine is presented. The program mechanism is described and the F100 test vehicles utilized are illustrated. Technology items were addressed in the areas of swirl augmentation, flutter phenomenon, advanced electronic control logic theory, strain gage technology and distortion sensitivity. associated test programs are described. The FSER approach utilizes existing state of the art engine hardware to evaluate advanced technology concepts and problam areas. Aerodynamic phenomenon previously not considered by design systems were identified and incorporated into industry design tools. AWH

N79-30191\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

PERFORMANCE OF TWO-STAGE FAN WITH A FIRST-STAGE ROTOR REDESIGNED TO ACCOUNT FOR THE PRESENCE OF A PART-SPAN DAMPER

William T. Gorrell and Donald C. Yrasek Sep. 1979 72 p. refs

NASA-TP-1483. E-9786. AVRADCOM-TR-79-10) Avail: NTIS HC AJ4/MF A01 CSCL 21E

The NASA two-stage fan was tested with a redesigned first-stage intor the redesign included a new design approach to account for the presence of a part-span damper. At design speed the fan achieved a peak efficiency of 0.803, which is 19 perceitage points higher than the original design. The peak efficiencies of the first stage and first rotor were 0.789 and 0.821 respectively. An improvement in efficiency of up to 5 percentage points in the damper region was achieved over the original large damper version. The stall margin, based on flow conditions at peak efficiency, was 10 percent at design Author

N79-31210\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

AN OVERVIEW OF NASA RESEARCH ON POSITIVE DISPLACEMENT TYPE GENERAL AVIATION ENGINES

E E Kempke and E A Willis 1979 40 p refs Presented at the Aircraft Systems and Technol Meeting N. Y., 20-22 Aug. 1979 sponsored by AIAA

(NASA-TM-79254, E-165, AIAA-79-1824) Avail, NTIS HC A03/MF A01 CSCL 21E

The general aviation positive displacement engine program encompassing conventional, lightweight diesel, and rotary combustion engines is described. Lean operation of current production type spark ignition engines and advanced alternative engine concepts are emphasized JMS

N79-31213°# National Aeronautics and Space Administration. Lewis Research Center Cleveland, Ohio.

AFRODYNAMIC PERFORMANCE OF 138-PRESSURE-RATIO, VARIABLE PITCH FAN STAGE

Royce D Moore and Walter M Osborn Sep 1979 71 p (NASA-TP-1502, E-9700) Avail NTIS HC A04/MF A01 CSCL

The performance of a variable pitch fan stage tested over a range of blade setting angles, speeds, and flows is presented The fan was designed for a tip speed of 289.6 m/sec and a flow of 29 6 kg/sec. The measured performance agreed reasonably well with the design point. The stall margin was only 5 percent. Static thrust values along an ope ting line ranged from less than 15 to over 115 percent of that at design angle as the blade setting angle was varied from 25 degrees (closed) to -8 Jegrees (opened). The use of casing treatment increased the stall margin to 20 f percent but decreased efficiency by 4 percenting points. AWH

N79-31214°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

AERODYNAMIC PERFORMANCE OF AXIAL-FLOW FAN STAGE OPERATED AT NINE INLET GUIDE VANE AN-GLES

Royce D. Moore and Lonnie Reid Sep. 1979 43 p refs (NASA-TP-1510: E-9714) Avail NTIS HC A03/MF A01 CSCL 21E

The overall performance of a fan stage with nine inlet guide vane angle settings is presented. These data were obtained over the stable flow range at speeds from 60 to 120 percent of design for vane setting angles from -25 to 42.5 degrees. At design speed and design inlet guide vane angle, the stage has a peak efficiency of 0.892 at a pressure ratio of 1.322 and a flow of 25 31 kg/s. The stall margin based on peak efficiency and stall was 20 percent. Based on an operating line passing through the peak efficiency point at the design setting angle. the useful operating range of the stage at design speed is limited by stall at the positive setting angles and by choke at the negative angles. At design the calculated static thrust along the operating line varied from 68 to 114 percent of that obtained at design setting angle.

A79-10792 \* # Wide range operation of advanced low NOx aircraft gas turbine combustors. P. B. Roberts, R. J. Fiorito (Solar Turbines International, San Diego, Calif.), and H. F. Butze (NASA, Lawis Research Center, Air Breathing Engines Div., Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, London, England, Apr. 9-13, 1978, Paper 78-GT-128. 13 p. 6 refs. Members, \$1.50; nonmembers, \$3.00. NASA-supported research.

The paper summarizes the results of an experimental test rig program designed to define and demonstrates techniques which would allow the jet-induced circulation and vortex air blast combustors to operate stably with acceptable emissions at simulated engine idle without compromise to the low NOx emissions under the high-altitude supersonic cruise condition. The discussion focuses on the test results of the key combustor modifications for both the simulated engine idle and cruise conditions. Several rangeaugmentation techniques are demonstrated that allow the leanreaction premixed aircraft gas turbine combustor to operate with low NOx emissons at engine cruise and acceptable CO and UHC levels at engine idle. These techniques involve several combinations, including variable geometry and fuel switching designs.

A79-11600 \* # Impact of future fuel properties on aircraft engines and fuel systems. R. A. Rudey and J. S. Grobman (NASA, Lewis Research Center, Cleveland, Ohio) NATO, AGARD, Lecture Series on Energy Conservation in Aircraft Propulsion, 96th, Munich, West Germany, Oct. 26, 27, 1978, Paper, 32 p. 20 refs.

From current projections of the availability of high-quality petroleum crude oils, it is becoming increasingly apparent that the pecifications for hydrocarbon jet fuels may have to be modified. The problems that are most likely to be encountered as a result of these modifications relate to engine performance, component dura bility and maintenance, and aircraft fuel-system performance. The effect on engine performance will be associated with changes in specific fuel consumption, ignition at relight limits, at exhaust emissions. Durability and maintenance will be affected by increases in combustor liner temperatures, carbon deposition, gum formation

in fuel nozzles, and erosion and corrosion of turbine blades and vanes. Aircraft fuel-system performance will be affected by increased deposits in fuel-system heat exchangers and changes in the pumpability and flowability of the fuel. The severity of the potential problems is described in terms of the fuel characteristics most likely to change in the future. Recent data that evaluate the ability of currentechnology aircraft to accept fuel specification changes are presented, and selected technological advances that can reduce the severity of the problems are described and discussed. (Author)

A79-14796 \* # Correlation of combustor acoustic power levels inferred from internal fluctuating pressure measurements. U. H. vor. Glahn (NASA, Lewis Research Center, Cleveland, Ohio). Acoustical Society of America, Meeting, 96th, Honolulu, Hawaii, Nov. 26-Dec. 1, 1978, Paper. 24 p. 12 refs.

Combustion chamber acoustic power levels inferred from internal fluctuating pressure measurements are correlated with operating conditions and chamber geometries over a wide range. The variables include considerations of chamber design (can, annular, and reverse-flow annular) and size, number of fuel nozzles, burner staging and fuel split, airflow and heat release rates, and chamber inlet pressure and temperature levels. The correlated data include those obtained with combustion component development rigs as well as engines. (Author)

A79-17029 Predicted inlet gas temperatures for tungsten fiber reinforced superalloy turbine blades. E. A. Winsa, L. J. Westfall, and D. W. Petrasek (NASA, Lewis Research Center, Cleveland, Ohio). In: ICCM/2; Proceedings of the Second International Conference on Composite Materials, Toronto, Canada, April 16-20, 1978. (A79-16981 05-24) Warrendale, Pa., Meta lurgical Society of AIME, 1978, p. 840-857, 23 refs.

A procedure is presented for predicting the magnitude of the turbine inlet gas temperatures potentially achievable using first generation tungsten fiber reinforcid superalloys (TFRS) turbine blades. Both uncoated blades and blades with thermal barrier coatings are considered. The thermal conductivities of two representative TFRS were measured over a range of temperatures. The results show that cooled TFRS blades may allow significantly higher gas temperatures than are possible with superalloy blades. For one design, the difference is about 150-200 K. M.L.

A79-19698 \* // Calculation of the three-dimensional flow field in supersonic inlets at angle of attack using a bicharacteristic method with discrete shock wave fitting. J. Vadyak, J. D. Hoffman (Purdue University, West Lafayette, Ind.), and A. R. Bishop (NASA, Lewis Research Center, Wind Tunnel and Flight Div., Cieveland, Ohiol. American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0379. 11 p. 11 refs. Grants No. NGR-15-005-162; No. NGR-15-005-191.

An analysis is presented for calculating the flow field in supersonic mixed-compression aircraft inlets operating at angle of attack. The flow field is computed by a steady three-dimensional bicharacteristic method. The bow shock wave and the reflected internal shock wave system are computed by a three-dimensional discrete shock wave fitting procedure. Viscous and thermal diffusion may be included as source terms in the bicharacteristic method. A production type computer program capable of determining the flow field in a variety of axisymmetric mixed-compression supersonic inlets is available. The results of the present analysis agree well with those produced by the two-dimensional method of characteristics when axisymmetric flow fields are computed. For three-dimensional flow fields, the results of the present analysis agree well with experimental data except in regions of high viscous interaction and wondary layer removal. The present analysis does not compute the boundary layer, nor does it account for boundary layer bleed. (Author)

A79-20078 \* # Fuel conservative aircraft engine technology. D. L. Nored (NASA, Lewis Research Center, Cleveland, Ohio). In: International Council of the Aeronautical Sciences, Congress, 11th, Lisbon, Portugal, September 10-16, 1978, Proceedings, Volume 1. (A79-20076 06-01) Cologne, International Council of the Aeronautical Sciences Secretariat (DGLR), 1978, p. 11-26, 22 refs.

NASA's Aircraft Energy Efficiency Program, initiated in an effort to minimize the adverse impact of the worldwide fuel crisis, will develop technology for more fuel-efficient subsonic transport aircraft. The program includes three major propulsion projects: (1) Engine Component Improvement, directed at current engines, (2) Energy Efficient Engine, directed at new turbofan engines, and (3) Advanced Turboprops, directed at technology for advanced turboprop-powered aircraft. The present paper reviews the current status of each of these projects and describes some of the technologies and recent accomplishments.

A79-20880 \* # Impact behavior of filament-would graphite/epoxy fan blades, K. J. Bowles (NASA, Lewis Research Center, Cleveland, Ohio). Society for the Advancement of Material and Process Engineering, National Symposium and Exhibition, 23rd, Anaheim, Calif., May 2-4, 1978, Paper. 18 p.

The fabrication and impact tests of graphite///poxy filament wound fan blades are discussed. Blades which were spin tested at tip speeds up to 305 m/sec retained their structural integrity. Two blades were each impacted with a 454-g slice of a 908-g simulated bird at a tip speed of 263 deg and impact angles of 22 deg and 32 deg. The impact tests were recorded with high-speed movie film. The blade which was impacted at 22 deg sustained some root delamination but remained intact. The 32 deg impact separated the blade from the root. No local damage other than leading-edge debonding was observed for either blade. The results of a failure mode analysis are also discussed. (Author)

A79-23509 \* # Effect of lip and centerbody geometry on aerodynamic performance of inlets for tilting-nacelle VTOL aircraft, R. R. Burley (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0381, 25 p. 8 refs.

Inlets for tilt-nacelle VTOL aircraft must operate over a wide range of incidence angles and engine weight flows without internal flow separation. Wind tunnel tests of scale model inlets were conducted to evaluate the effectiveness of three geometric variables to provide this capability. Increasing the lip contraction ratio increased the separation angle at all engine weight flows. The optimum axial location of the centerbody occurred when its leading edge was located just downstream of the inlet lip. Compared with a short centerbody, the optimum location of the centerbody resulted in an increase in separation angle at all engine weight flows. Decreasing the lip major-to-minor-axis ratio increased the separation angle at the lower engine weight flows. (Author)

A79-23512 \* # Effect of forward velocity and crosswind on the reverse-thrust performance of a variable-pitch fan engine. D. C. Reemsnyder and D. A. Sagerser (NASA, Lewis Research Center, Cleveland, Olivo). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0105, 20 p. 12 refs.

Variable-pitch-fan engines may be attractive for future short-haul aircraft if sufficient reverse thrust is available for aircraft deceleration after touchdown. Thrust reversal is obtained in these engines by changing fan blade pitch about 90 deg, which causes the fan airflow to enter the fan duct nozzle and exhaust through the fan inlet. This capability would eliminate the heavy and costly thrust reverser system required for current fixed-pitch turbofan engines. NASA has, therefore, supported the development of advanced technology for a quiet, clean, high-bypass-ratio turbofan engine for future short-haul aircraft. In connection with this program, tests

were conducted to determine the effect of forward velocity and angle of attack on steady-state reverse-thrust performance. Other objectives of the tests were related to the determination of the effect of forward velocity on forward-to-reverse thrust transient performance and the determination of the effectiveness of an overshoot blade angle technique to establish reverse thrust during a transient. The results of the tests are discussed.

G.R.

A79-25856 \* # Lean combustion limits of a confined premixed-prevaporized propane jet. K. L. Huck (NASA, Lewis Research Center, Cleveland, Ohio; Martin Marietta Aerospace, Bethesda, Md.). American Institute of Aeronautics and Astronautics, Annual Meeting and Technical Display. 15th, Washington, D.C., Feb. 6-8, 1979, Paper 79-0538. 9 p. 10 refs.

An experimental study was carried out to determine the effects of jet velocity and confinement on lean premixed-prevaporized propane/air blowout limits. The combustor consisted of a single hole flameholder within a quartz liner. Five flameholder plates and two quartz liners were used. Lean stability limits were mapped for confined propane jet in cylindrical combustor. Three zones of flame stability were observed depending on the liner and jet Reynolds number and the combustor geometry. At low Reynolds number the combustor was jet stabilized. As the Reynolds number was increased the combustor became either recirculation zone stabilized, or for small recirculation zone step sizes, the combustor was wall stabilized. The factors affecting stability seem to be the Reynolds numbers of the liner and inlet jet along with the flameholder step size. Stability was achieved at both laminar and turbulent conditions.

S.D.

A79-25870 \* # NASA research on general aviation power plants. W. L. Stewart, R. J. Weber, E. A. Willis, and G. K. Sievers (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Annual Meeting and Technical Display, 15th, Washington, D.C., Feb. 6-8, 1979, Faper 79-0561. 10 p. 7 refs.

Research activities within NASA to support general aviation industry in improving propulsion engines are described. Near-term objectives include improvements of gasoline piston engines to achieve fuel savings and reduce emissions well below EPA levels. To meet the longer term goals, advanced combustion research has been considered as essential in obtaining further improvements in BSFC (break specific fuel consumption). Modifications of an aircraft rotary engine were tested and it was found that by increasing the compression ratio and other refinements the BSFC was improved by 15%. The applicability of available large turbofan engine technology to small engines in order to obtain significant reductions in noise and pollutant emissions is being tested. Studies have been conducted at exploring the possibility of achieving high improvements in cost and performance for turboprop engines of less than 1000 horsepower.

A.A

A79-25880 \* Prop-fan propulsion - Its status and potential. J. F. Dugan, Jr. (NASA, Lewis Research Center, Cleveland, Ohio), B. S. Gatzen, and W. M. Adamson (United Technologies Corp., Hartford, Conn.). Society of Automotive Engineers, Aerospacial Meeting, San Diego, Calif., Nov. 27-30, 1978, Paper 780995. 21 p. 43 refs.

Studies have established that advanced turboprop (p op-fan) equipped aircraft will reduce fuel consumption by 15 to 20 percent compared to aircraft equipped with high-bypass turbofar engines of equivalent technology. A reduction in direct operating costs of approximately 10 percent has been identified for commircial aircraft as well as approximately 20 percent lower gross weigh, airplane for long endurance military missions. The prop-fan propultion system is being investigated as part of the NASA Aircraft Energy Efficiency program which includes both analytical studies and experimental tests. The experimental work encompasses performance and acoustic wind tunnel tests on several prop-fan models. The prop-fan technology status is reviewed in the major areas of performance, installed

effects, cabin noise, blade structure and maintenance cost. Also, further activities required to complete the technical validation of prop-fans are described. (Author)

A79-25885 \* An in-place recalibration technique to extend the temperature capability of capacitance-sensing, rotor-blade-tip-dearance measurement systems. J. Barranger (NASA, Lewis Research Center, Cleveland, Ohio). Society of Automotive Engineers, Aerospace Meeting, San Diego, Calif., Nov. 27-30, 1978, Paper 781003. 14 p.

It is known that capacitance-sensing, rotor-blade-tip-clearance measurement systems suffer from a strong dependency on probe tip temperature and humidity. A novel in-place recalibration technique partly overcomes this problem through a simple modification of the electronics that permits a scale factor correction. The technique is used to reduce the errors in a commercial system by more than 50 percent up to a temperature of 370 C (700 F). A probe design is proposed to further raise the maximum temperature capability of the measurement system. (Author)

A79-26877 \* # Measured and predicted noise of the AVCO-Lycoming YF-102 turbofan engine. B. J. Clark, J. G. McArdle, and L. Homyak (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0641. 9 p. B refs.

Acoustic testing of the AVCO-Lycoming YF-102 turbofan engine was done on a static test stand at Lewis Research Center in support of the Ouiet Short-Haul Research Aircraft (OSRA) acoustic design. Overall noise levels are dominated by the fan noise emanating from the exhaust duct, except at high power settings when combination tones are generated in the fan inlet. Component noise levels, calculated by noise prediction methods developed at Lewis Research Center for the ANOP program, are in reasonable agreement with the measured results. Far-field microphones placed at ground level were found superior to those at engine centerline height, even at high frequencies. (Author)

A79-26881 \* # Full-scale engine tests of bulk absorber acoustic inlet treatment. L. J. Heidelberg and L. Homyak (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0600. 10 p. 6 refs.

Three different densities of Kevlar bulk absorber fan inlet treatment were tested on a YF 102 turbofan engine. This bulk absorber material may have potential for flight application. Far-field noise measurements were made and the attenuation properties of the three treatment densities were compared. In addition the best bulk treatment was compared to the best single degree of freedom, SDOF (honeycomb and perforated cover sheet) treatment from another investigation. Although the density was varied over a large range, (3 to 1) the effect on attenuation was small. The highest density treatment, 11.8 lb/cu ft, had a somewhat broader attenuation bandwidth. The comparison of the best bulk and SDOF treatments showed the bulk to have a greater attenuation bandwidth. At the design frequency both types of treatment had almost equal performance. (Author)

A79-26926 \* # Evaluation of two inflow control devices for flight simulation of fan noise using a JT15D engine. W. L. Jones, J. G. McArdle, and L. Homyak (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979. Paper 79-0654. 11 p. 9 refs.

Two inflow control devices, (ICD's) one in-duct and the other external to the duct, were tested on a JT15D engine to determine their ability to remove inflow turbulence without altering the sound

transmission to the far field. The objective of the program was to develop means of accurately simulating flight fan noise on ground static test stands. The results generally indicated that both the in-duct and external ICD's were effective in reducing the inflow turbulence and the fan blade passing frequency tone generated by the turbulence. The external ICD was essentially transparent to the propagating fan tone but the in-duct ICD caused attenuation under most conditions. (Author)

A79-26944 ° # Analysis of radiation patterns of interaction tones generated by inlet rods in the JT15D engine. M. F. Heidmann, A. V. Saule, and J. G. McArdle (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0581. 14 p. 10 refs.

A79-29383 \* # Effect of broadened-specification fuels on aircraft engines and fuel systems. R. A. Rudey (NASA, Lewis Research Center, Cleveland, Ohiol. In: International Symposium on Air Breathing Engines, 4th, Orlando, Fla., April 1-6, 1979, Proceedings. (A79-29376 11-07) New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 53-69, 23 refs. (AIAA 79-7008)

A wide variety of studies on the potential effects of broadened-specification fuels on future aircraft engines and fuel systems are summarized. The compositions and characteristics of aircraft fuels that may be derived from current and future crude-oil sources are described, and the most critical properties that may affect aircraft engines and fuel systems are identified and discussed. The problems that are most likely to be encountered because of changes in selected fuel properties are described; and the related effects on engine performance, component durability and maintenance, and aircraft fuel-system performance are discussed. The ability of current technology to accept possible future fuel-specification changes is discussed, and selected technological advances that can red-ice the severity of the potential problems are illustrated. (Author)

A79-29386 \* # Characteristics of aeroelastic instabilities in turbomachinery - NASA full scale engine test results. J. F. Lubomski (NASA, Lewis Research Center, Cleveland, Ohio). In: International Symposium on Air Breathing Engines, 4th, Orlando, Fla., April 1-6, 1979, Proceedings. (A79-29376 11-07) New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 91-102. 8 refs. (AIAA 79-7011)

Several aeromechanical programs have been conducted in the NASA/USAF Joint Engine System Research Programs. The scope of these programs, the instrumentation, data acquisition and reduction, and the test results are discussed. Data pertinent to four different instabilities were acquired; two types of stall flutter, choke flutter and a system mode instability. The data indicates that each instability has its own unique characteristics. These characteristics are described.

(Author)

A79-30521 \* # Effect of rotor tip clearance and configuration on overall performance of a 12.77-centimeter tip diameter axial-flow turbine. J. E. Haas (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio) and M. G. Kofskey (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-42. 9 p. 7 refs. Members, \$1.50; nonmembers, \$3.00.

An extensive experimental investigation was made to determine the effect of varying the rotor tip clearance of a 12.77-cm-tip diameter, single-stage, axiai-flow reaction turbine. In this investigation, the rotor tip clearance was obtained by use of a recess in the casing above the rotor blades and also by use of a reduced blade height. For the recessed casing configuration, the optimum rotor blade height was found to be the one where the rotor tip diameter

was equal to the stator tip diameter. The tip clearance loss associated with this optimum recessed casing configuration was less than that for the reduced blade height configuration.

(Author)

A79-30553 \* # Thermal-structural mission analyses of air-cooled gas turbine blades. A. Kaufman and R. E. Gaugler (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-19.11 p. 8 refs.

Cyclic temperature and stress-strain states in cooled turbine blades were calculated for a simulated mission of an advanced technology aircraft engine. TACTI (three dimensional heat transfer) and MARC (nonlinear structural analysis) computer programs were used to analyze impingement cooled airfoils, with and without leading-edge film cooling. Creep was the predominant damage mode, particularly around film cooling holes. Radially angled holes exhibited less creep than holes normal to surface. Beam-type analyses of all-impingement cooled airfoils gave fair agreement with MARC results for initial creep.

(Author)

A79-30557 \* # The Advanced Low-Emissions Catalytic-Combustor Program: Phase I - Description and status, A. J. Szaniszlo (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Ti Dine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-192. 11 p. 22 refs.

The Advanced Low-Einissions Catalytic-Combustor Program is an ongoing three-phase contract effort with the primary objective of evolving the technology required for incorporating catalytic combustors into advanced aircraft gas-turbine engines. Phase I is currently in progress. At the present time, analytical evaluation is being conducted on advanced catalytic-combustor concepts, including variable geometry, with their known inherent potential advantages of low-level pollutant emissions, widened combustion stability limits, and reduced pattern factor for longer turbine life. Phases II and III will consist of experimental evaluation of the most promising concepts. (Author)

A79-30559 \* # Effect of flight loads on turbofan engine performan. deterioration. E. G. Stakolich (NASA, Lewis Research Conter, Cleveland, Ohiol, A., Jay, E. S. Todd (United Technologies Corp., Pratt and Whitney Aircraft, East Hartford, Conn.), P. G. Kafka and J. L. White (Boeing Commercial Airplane Co., Renton, Wash.). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar., 12-15, 1979, Paper. 21 p.

A significant percentage of high-bypass-ratio turbofan engine performance deterioration is caused by an increase in operating clearance between fan/compressor and turbine blades and their outer air seals. These increased clearances result from rubs induced by a combination of engine power transients and aircraft flight loads. An analytical technique for predicting the effect of quasi-steady state aircraft flight loads on engine performance deterioration has been developed and is presented. Thrust, aerodynamic and inertia loads are considered. Analytical results are shown and compared to actual engine test experience. (Author)

A79-30560 \* # The GATE studies - Assessing the potential of future small general aviation turbine engines. W. C. Strack (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper, 22 p.

Four studies have been completed that explore the opportunities for future General Aviation Turbine Engines (GATE) in the 150-1000 SHP class. These studies forecasted the potential impact of advanced technology turbine engines in the post-1988 market, identi-

fied important aircraft and missions, desirable engine sizes, engine performance and cost goals. Parametric evaluations of various engine cycles, configurations, design features, and advanced technology elements defined baseline conceptual engines for each of the important missions identified by the market analysis. Both fixed-wing and helicopter aircraft, and turboshaft, turboprop, and turbofan engines were considered. Key technology areas were recommended for NASA support in order to realize proposed improvements. (Author)

A79-32329 \* # An off-design correlation of part span damper losses through transonic axial fan rotors. W. B. Roberts (Nielsen Engineering and Research, Inc., Mountain View, Calif.), J. E. Crouse, and D. M. Sandercock (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-67-6. 15 p. 21 refs. Members, \$1.50; nonmembers, \$3.00. Grant No. NsG-3133.

The experimental performance of 10 transonic fan rotors was used to correlate losses caused by midchord part-span dampers (PSD) during off-design operation between 50 and 100 percent of design speed. The design tip speed for the rotors used varied from 419 to 425 m/s and the design pressure ratios from 1.6 to 2.0. The loss attributable to the damper and the region influenced along the blade height was correlated with relevant aerodynamic and geometric parameters. The losses at the design point were estimated by a previously reported correlation (Roberts, 1978). Using this as a base, the off-design losses were correlated with variation in blade suction surface incidence. A check with independent data showed that the prediction of damper losses and region of influence was fair to good for most of the off-design data examined. (Author)

A79:36729 Preliminary QCGAT program test results. R. W. Koenig and G. K. Sievers (NASA, Lewis Research Center, Cleveland, Ohio). Society of Automotive Engineers, Business Aircraft Meeting and Exposition, Wichita, Kan., Apr. 3-6, 1979, Paper 790596. 11 p.

The paper presents the NASA Lewis program to demonstrate that large engine technology can be applied to general aviation engines to reduce noise, emissions, and fuel consumption. After a Phase I study, two contractors, Garrett AiResearch and AVCO-Lycoming, were selected to design, manufacture, assemble, test, and deliver their Quiet, Clean, General Aviation Turbofan (QCGAT) engines to NASA. Noise, emission, and performance goals and how well they were met are discussed. Noise goals involve take off rioise 3.5 n. mi. from runway threshold, sideline noise at .25 n mi. and approach noise 1 n.mi. from the runway at an altitude of 370 ft. The AiResearch engines power a stretched Learjet 35 and the Lycoming a specially conceived Beech executive jet, resulting in differing power goals. Thus the thrust goal for the Lycoming was 1622 lb. while the AiResearch goal was 3937 lb. Cruise thrust goals were 485 lb. at Mach 0.6 at 25,000 ft. and 903 lb at Mach 0.8 at 40,000 ft. respectively. The design of both engines, based on existing cores, is studied, noting such special QCG AT features as new reduction gears, combustor and power turbine. Test results are given, indicating that while the goals for noise and thrust were met those for emissions were only partially met.

A79-36747 \* New opportunities for future small civil turbine engines - Overviewing the GATE studies W. C. Strack (NASA, Lewis Research Center, Cleveland, Ohiol. Society of Automotive Engineers, Business Aircraft Meeting and Exposition, Wichita, Kan., Apr. 3-6, 1979, Paper 790619, 14 p.

This paper presents an overview of four independent studies that explore the opportunities for future General Aviation Turbine Engines (GATE) in the 150-1000 SHP class. Detroit Diesel Allison, Garrett/AiResearch, Teledyne CAE, and Williams Research participated along with several airframers. These studies forecasted the potential impact of advanced technology turbine engines in the post-1988 market, identified important aircraft and missions, de-

sirable engine sizes, engine performance and cost gcals. Parametric evaluations of various ungine cycles, configurations, design features, and advanced technology elements defined baseline conceptual engines for each of the important missions identified by the market analysis. Both fixed-wing and helicopter aircraft, and turboshaft, turboprop, and turbofan engines were considered. All four companies predicted sizable performance gains (e.g., 20% SFC decrease), and three predicted large engine cost reductions of sufficient magnitude to challenge the reciprocating engine in the 300-500 SHP class. Key technology areas were recommended for NASA support in order to realize these improvements. (Author)

A79-36759 Wind tunnel perfor nince of four energy efficient propellers designed for Mach 0.8 cruise. R. J. Jeracki, D. C. Mikkelson, and B. J. Blaha (NASA, Lewis Research Center, Cleveland, Ohio). Society of Automotive Engineers, Business Aircraft Meeting and Exposition, Wichita, Kan., Apr. 3-6, 1979, Paper 790573, 22 p. 44 refs.

For the advanced turboprop to be competitive with proposed advanced turbofan-powered aircraft, it must have high propulsive efficiency at Mach 0.8 cruise above 9.144-km altitude with an acceptable cabin noise environment. Four 8-bladed propeller models are designed employing various concepts to reduce compressibility losses. Wind tunnel tests are conducted at zero model incidence to the free-stream flow. Aerodynamic and acoustic for results are presented and discussed. It is shown that the aeroacoustically designed configuration (SR-3) with 45 deg of tip sweep and an area-ruled spinner yields the highest propulsive efficiency (78.7% at Mach 0.8, 3.06 advance ratio, and 1.7 power coefficient), with an improvement of about 3% over the straight bladed configuration (SR-2, with zero-degree sweep). The phase-interference concept for noise reduction used in SR-3 yields about 5-6 dB reduction as compared to SR-2. SD

A79-36760 \* Effects of air injection on a turbocharged Teledyne Continental Motors TSIO-360-C engine. D. V. Cosgrove and E. E. Kempke (NASA, Lewis Research Center, Cleveland, Ohio). Society of Automotive Engineers, Business Aircraft Meeting and Exposition, Wichita, Kan., Apr. 3-6, 1979, Paper 790607. 35 p. 7

Results are presented for tests performed to assess the effects of exhaust manifold injection air flow rate on emissions and on exhaust gas temperature and turbine inlet temperature for a range of engine operating conditions (speed, torque, and fuel-air ratios) of a fuel-injected turbocharged six-cylinder air-cooled Teledyne Continental Motors TSIO-360-C engine. Air injection into the exhaust gas at 80 F resulted in a decrease in hydrocarbons and carbon monoxide while exceeding the maximum recommended turbine inlet temperature of 1650 F at the full rich mixture of the engine. The EPA standards could be met within present turbine inlet temperature limits using commercialty available air pumps, provided that the fuel-air ratios were leaned in the taxi, climb, and approach modes.

S.D

A79:38969 \* # Effect of shocks on film cooling of a full scale turbojet exhaust nozzle having an external expansion surface. D. M. Straight (NASA, Lewis Research Center, Cleveland, Ohio). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18:20, 1979, AIAA Paper 79-1170. 13 p. 17 refs.

Cooling is one of the critical technologies for efficient design of exhaust nozzles, especially for the developing technology of non-axisymmetric (2D) nozzles for future aircraft applications. Several promising 2D nozzle designs have external expansion surfaces which need to be cooled. Engine data are scarce, however, on nozzle cooling effectiveness in the supersonic flow environment (with shocks) that exists along external expansion surfaces. This paper will present experimental film cooling data obtained during exploratory testing with an axisymmetric plug nozzle having external expansion and installed on an afterburning turbojet engine in an altitude test

facility. The data obtained shows that the shocks and local hot gas stream conditions have a marked effect on film cooling effectiveness. An existing film cooling correlation is adequate at some operating conditions but inadequate at other conditions such as in separated flow regions resulting from shock-boundary-layer interactions.

(Author)

A79-38961 \* # Test verification of a turbofan partial swirl afterburner. K. J. Hanloser (United Technologies Corp., Pratt and Whitney Aircraft Group, West Palm Beach, Fla.) and R. Cullom (NASA, Lawis Research Center, Cleveland, Ohio). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1199. 6 p. 6 refs.

Flamespreading velocities exceeding conventional turbulent flamespreading values were demonstrated in a strong centrifugal flow field. This centrifugal flow field flamespreading concept was integrated into an F100 turbofan engine afterburner by introducing swirling airflow into the afterburner. Successful tests were conducted on F100 Engine P072 at sea level and at altitude conditions in a test chamber. This paper summarizes the design approach, engine design verification tests and performance data. Engine tests showed the swirl afterburner increased fuel-air capability improving combustion stability at adverse conditions for combustion in the engine flight envelope. No engine performance or durability degradation was observed. (Author)

A79:38984 \* # Application of digital controls on the quiet clean short haul experimental engines. A. A. Saunders, Jr. (General Electric Co., Aircraft Engine Group, Cincinnati, Ohio) and A. C. Hoffman (NASA, Lewis Research Center, Cleveland, Ohio). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18:20, 1979, AIAA Paper 79:1203. 8 p. 6 refs. Contract No. NAS3:18021.

The digital control systems for the Under-the-Wing (UTW) and Over-the-Wing (OTW) engines developed on the NASA/General Electric Quiet Clean Shorthaul Experimental Engine (QCSEE) program are described. The system to control engine variables includes three major functional parts: system sensors, digital control and system actuators. One of the primary control system functions is to prevent the engine from exceeding speed or temperature limits. The UTW control system also provides fault detection and condition. monitoring. The control system requirements for the OTW engine are essentially the same as the UTW engine, however the inlet Mach number control requirement is eliminated, and failure indication and corrective action and full authority digital control are added. The digital controls scheduled the engine variables and maintained engine operation within all physical limits throughout the test program of approximately 200 hours of operation and provided stable and accurate control of both engines.

A79-39031 \* # Combined pressure and temperature distortion effects on internal flow of a turbofan engine. W. M. Braithwaite and R. H. Soeder (NASA), Lewis Research Center, Cleveland, Ohio). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1309. 11 p. 13 refs.

The flow characteristics obtained experimentally for the compression of a 2-spool TF-30-P-3 turbofan engine operating with 180 grad combined pressure and temperature distortion in the inlet flow are presented. The analytical model (Mazzawv and Banks, 1976), "tuned" during Lewis testing, was used for pretest predictions of the effects that these distortions would have on the engine flow characteristics and the limiting distortion values. The effect of inlet flow distortion on the performance of the engine is discussed, including. (1) the flow between a screen mounted in the inlet duct and the inlet guide vanes; (2) the flow through the compression system; and (3) the effects of the combined distortion and its orientation on the compressor stability limits. It is concluded that the model used in this program was capable of predicting the effects of total pressure, total temperature and combined total pressure-total

temperature distortions in terms of flow profiles, inlet flow angles and attenuation of the distortions through the compressor system. It was also capable of predicting the trends of the limiting values experienced with various orientations of the combined distortions.

V.T.

A." ±39034 ° # Lean, premixed, prevaporized combotion for aircraft gas turbine engines. E. J. Mularz (NASA, Lewis Research Center; U.S. Army, Propulsion Laboratory, Cleveland, Ohio). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, New, June 18-20, 1979, AIAA Paper 79-1318. 13 p. 24 refs.

The application of lean, premixed, prevaporized combustion to aircraft gas turbine engine systems can result in benefits in terms of superior combustion performance, improved combustor and turbine durability, and environmentally acceptable pollutant emissions. Lean, premixed, prevaporized combustion is particularly attractive for reducing the oxides of nitrogen emissions during high altitude cruise. The NASA Stratospheric Cruise Emission Reduction Program will evolve and demonstrate lean, premixed, prevaporized combustion technology for aircraft engines. This multiphased program is described. In addition, the various elements of the Fundamental Studies Phase of the program are reviewed, and results to date of many of these studies are summarized. (Author)

A79-39804 \* # Materials and structural aspects of advanced gas-turbine helicoptar engines. J. C. Freche (NASA, Lewis Research Center, Cleveland, Ohio) and J. Acurio (U.S. Army, Propulsio: Laboratory, Cleveland, Ohio). Association Aéronautique et Astronautique de France, International Congress in Aeronautics, Paris, France, June 6-8, 1979, Paper, 63 p. 122 refs.

Advances in materials, coatings, turbine cooling technology, structural and design concepts, and component-life prediction of helicopter gas-turbine-engine components are presented. Stationary parts including the inlet particle separator, the front frame, rotor tip seals, vanes and combustors and rotating components - compressor blades, disks, and turbine blades - are discussed. Advanced composite materials are considered for the front frame and compressor blades, prealloyed powder superalloys will increase strength and reduce costs of disks, the oxide dispersion strengthened alloys will have 100C higher use temperature in combustors and vanes than conventional superalloys, ceramics will provide the highest use temperature of 1400C for stator vanes and 1370C for turbine blades, and directionally solidified eutectics will afford up to 50C temperature advantage at turbine blade operating conditions. Coatings for surface protection at higher surface temperatures and design trends in turbine cooling technology are discussed. New analytical methods of life prediction such as strain gage partitioning for high temperature prediction, fatigue life, computerized prediction of oxidation resistance, and advanced techniques for estimating coating life are described. A.T.

A79-39814 ° # Multivariable control altitude demonstration on the F100 turbofan engine. B. Lehtinen (NASA, Lewis Research Center, Cleveland, Ohio), R. L. DeHoff (Systems Control, Inc., Palo Alto, Calif.), and B. D. Hackney (United Technologies Corp., Pratt and Whitney Aircraft Group, West Palm Beach, Fla.). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Los Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1204. 2S p. 16 refs.

The control system designed under the Multivariable Control Synthesis (MVCS) program for the F100 turbofan engine is described. The MVCS program, applied the linear quadratic regulator (LOR) synthesis methods in the design of a multivariable engine control system to obtain enhanced performance from cross-coupled controls, maximum use of engine variable geometry, and a systematic design procedure that can be applied efficiently to new engine systems. Basic components of the control system, a reference value generator for deriving a desired equilibrium state and an approximate control vector, a transition model to produce compatible reference point trajectories during gross transients, gain schedules for producing feedback terms appropriate to the flight condition, and integral

switching logic to produce acceptable steady-state performance without engine operating limit exceedance are described and the details of the F100 implementation presented. The engine altitude test phase of the MVCS program, and engine responses in a variety of test operating points and power transitions are presented. A.T.

A79-40488 \* # A summary of NASA/Air Force Full Scale Engine Research programs using the F100 engine. W. J. Deskin (United Technologies Corp., Government Products Div., West Palm Beach, Fln.) and H. G. Hurrell (NASA, Lewis Research Center, Cleveland, Ohio). AIAA, SAF, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1306. 14 p. 20 refs.

This paper summarizes a joint NASA/Air Force Full Scale Engine Research (FSER) program conducted with the F100 engine during the period 1974 through 1979. The program mechanism is described and the F100 test vehicles utilized are illustrated. Technology items which have been addressed in the areas of swirl augmentation, flutter phenomenon, advanced electronic control logic theory, strain gage technology, and distortion sensitivity are identified and the associated test programs conducted at the NASA-Lewis Research Center are described. Results presented show that the FSER approach, which utilizes existing state-of-the-art engine hardware to evaluate advanced technology concepts and problem areas, can contribute a significant data base for future system applications. Aerodynamic phenomenon previously not considered by current design systems have been identified and incorporated into current ind stry design tools. (Author)

A79-47918 \* # Energy efficient aircraft engines. R. Chamberlin and B. Miller (NASA, Lewis Research Center, Energy Conservative Engines Office, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aircraft Systems and Technology Meeting, New York, N.Y., Aug. 20-22, 1979, Paper 79-1861. 11 p.

The three engine programs that constitute the propulsion portion of NASA's Aircraft Energy Efficiency Program are described, their status indicated, and anticipated improvements in SFC discussed. The three engine programs are: (1) engine component improvement, directed at current engines, (2) energy efficient engine, directed at new turbofan engines, and (3) advanced turboprops, directed at technology for advanced turboprop-powered aircraft with cruise speeds to Mach 0.8. Unique propulsion system interactive ties to the airframe resulting from engine design features to reduce fuel consumption are discussed. Emphasis is placed on the advanced turboprop since it offers the largest potential fuel savings of the three propulsion programs and also has the strongest interactive ties to the airframe. (Author)

A79-50208 \* QCSEE - The key to future short-haul air transport. C. C. Ciepluch (NASA, Lewis Research Center, Quiet, Clean, Short-Haul Experimental Engine Project Office, Cleveland, Ohio) and W. S. Willis (General Electric Co., Aircraft Engine Group, West Lynn, Mass.). ICAO Bulletin, vol. 34, Apr. 1979, p. 24-29.

The paper describes the design and test procedure for the OCSEE (quiet, clean, short-haul experimental engine). The engines designed for the YC-14 and YC-15 STOL aircraft, both use a very low fan pressure ratio to keep jet-flap noise about 3 dB below total system noise. Other noise reducing features discussed are the low tip speed fans and a carefully selected number of fan blades and vanes with adequate spacing between them. Attention is also given to the development of a low emissions combistor, and reduction of fan frame weight, through the use of graphite/epoxy material. The YC-15 engine also employs variable pitch fans to provide thrust reversal, thus saving weight. Finally, it is noted that the tests have proven that the engines could be configurated to meet the needs of a powered lift system without excessively compromising performance or weight.

A79-50333 \* Airborne atmospheric sampling system. U. R. C. Gustafsson (United Airlines, Inc., San Francisco, Calif.), P. J. Perkins, T. W. Nyland, M. W. Tiefermann, and T. J. Dudzinski (NASA, Lewis Research Center, Cleveland, Ohio). In: Learning to use our environment; Proceedings of the Twenty-fifth Annual Technical Meeting. Seattle, Wash., April 30-May 2, 1979. (A79-50326 22-42) Mount Prospect, III., Institute of Environmental Sciences, p. 48-57.

The atmospheric sampling system developed for use on board commercial airliners as part of the Global Atmospheric Sampling Program (GASP) is described. The automated air-constituent measuring system is installed in a Boeing 747 airliner below the passenger cabin floor near the nose wheel well. It consists of an air sample flow system, composed of air inlet and pressurization systems, computerized data acquisition and system control units which direct system operation in 15 modes, and commercial instruments significantly modified to measure low levels of atmospheric constituents (ozone, water vapor, nitrogen oxides, carbon monoxide, chlorofluoromethanes, particulates, condensation nuclei, sulfates and nicrates). Flight and meteorological data, including air temperature and altitude, are also recorded. The system is designed for servicing at 14-day intervals, and to require a minimum of aircrew involvement.

N79-10058® Pratt and Whitney Aircraft Group, West Palm Beach, Fla Government Products Div EVALUATION OF THE CYCLIC BEHAVIOR OF AIRCRAFT TURBINE DISK ALLOYS Final Report B. A. Cowles, D. L. Sims, and J. R. Warren Oct 1978—152 prefs (Contract NAS3-20367) (NASA-CR-159409; PWA-FR-10299) Avail. NTIS HC A08/MF A01 CSCL 218

Five aircraft turbine disk alloys representing various strength and processing histories were evaluated at 650 C to determine if recent strength advances in powder metallurgy have resulted in corresponding increases in low cycle fatigue (LCF) capability Controlled strain LCF tests and controlled load crack propagation tests were performed. Results were used for direct material comparisons and in the analysis of an advanced aircraft turbine disk, having a fixed design and operating cycle. Crack initiation lives were found to increase with increasing tensile yield strength, while resistance to fatigue crack propagation generally decreased with increasing strength.

Author

N79-10061\*# Mechanical Technology, Inc., Latham, N. Y STUDY OF T53 ENGINE VIBRATION Final Report Thomas J., Walter Nov. 1978 60 p. refs (Contract NAS3-20609) (NASA-CR-135449, MTI-78TR66) Avail. NTIS HC A04/MF A01 CSCL 21E

Vibration characteristics for overhauled T53 engines, including rejection rate, principal sources of vibration, and normal procedures taken by the overhaul center to reduce engine vibration are summarized. Analytical and experimental data were compared to determine the engine's dynamic response to unbalance forces with results showing that the engine operates through bending critical speeds. Present rigid rotor balancing techniques are incapable of compensating for the flexible rotor unbalance. A comparison of typical test cell and aircraft vibration levels disclosed significant differences in the engine's dynamic response. A probable spline shift phenomenon was uncovered and investigated Action items to control costs and reduce vibration levels were identified from analytical and experimental studies.

N79-11042\*# General Electric Co. Cincinnati, Ohio Engine Group

DEFINITION STUDY OF A VARIABLE CYCLE EXPERIMEN-TAL ENGINE (VCEE) AND ASSOCIATED TEST PROGRAM AND TEST PLAN Final Report, Sep. 1977 - Mar. 1978

R D Allan Oct 1978 198 p

(Contract NAS3-20810)

(NASA-CR-159419. NTIS R78AF(5568) Avail

HC A09/MF A01 CSCL 21E

The Definition Study of a Variable Cycle Experimental Engine (VCEE) and Associated Test Program and Test Plan, was initiated to identify the most cost effective program for a follow-on to the AST Test Bed Program The VCEE Study defined various subscale VCE's based on different available core engine components, and a full scale VCEE utilizing current technology. The cycles were selected, preliminary design accomplished and program plans and engineering costs developed for several program options. In addition to the VCEE program plans and options, a limited effort was applied to identifying programs that could logically be accomplished on the AST Test Bed Program VCE to extend the usefulness of this test hardware. Component programs were provided that could be accomplished prior to the start of a VCEE program

N79-11068\*# Detroit Diesel Allison, Indianapolis, Ind. Systems Group

DETERMINING AND IMPROVING LABYRINTH SEAL PERFORMANCE IN CURRENT AND ADVANCED HIGH PERFORMANCE GAS TURBINES

Harold L Stocker In AGARD Seal Technol in Gas Turbine Eng Aug 1978 22 p refs (For pr.mary document see N79-11056 02.071

(Contracts NAS3-20056, N00140-73-C-005)

N00140-74-C-0759)

Avail NTIS HC A13/MF A01 CSCL 21E

Abradable and honeycomb lands were evaluated with a conventional straight through seal using a static two dimensional (rectangular flowpath) seal rig and a rotating three dimensional seal rig. Test results show that some abradable lands leak significantly more than a solid-smooth land. However, honeycomb lands were found to reduce leakage up to 24 percent. Through aerodynamic testing, an advanced design labyrinth seal was developed which reduced leakage 54.2 percent compared to a conventional straight-through seal and 26.3 percent compared to a conventional stepped seal

#### N79-12088\* # General Electric Co., Cincinnati, Ohio EXPERIMENTAL CLEAN COMBUSTOR PROGRAM: PHASE 3: TURBULENCE MEASUREMENT ADDENDUM **Final Report**

J R Taylor Nov 1978 40 p refs (Contract NAS3-19736)

(NASA-CR-135422. R78AEG529) Avail HC A03/MF A01 CSCL 21E

Airflow turbulence parameters were measured in the high pressure, high temperature flow stream leaving the compressor of an operating gas turbine engine. A water cooled hot film turbulence probe was used to determine the turbulence intensity and length scale in the compressor exit flow stream of the CF6-50 engine Data were obtained only at idle operating conditions. At engine power levels above idle conditions, durability problems and erratic data readings were encountered with the turbulence measurement probes. Turbulence measurements were made at three radial immersions at a point 155 cm downstream of the compressor outlet guide vanes in the compressor exit diffuse: The passage height at this point is 5.54 cm. Data reduction was accomplished with a time-data fast Fourier transform (FFT) system. This system finds the power spectral density distribution (PSD) of a large number of data samples using a direct Fourier transform algorithm and finds the autocorrelation parameter for these data by doing an FFT analysis of the PSD curves for a series of time delay intervals Author

N79-13048\* General Electric Co., Cincinnsti, Ohio. Aircraft Engine Group

DEFINITION STUDY FOR VARIABLE CYCLE ENGINE TESTBED ENGINE AND ASSOCIATED TEST PROGRAM

John W. Vdovisk Nov. 1978 112 p

(Contract NAS3-20582A)

R78AEG551) (NASA-CR-159459;

NTIS

HC A06/MF A01 CSCL 21E

The product/study double bypess variable cycle engine (VCE) was updated to incorporate recent improvements. The effect of these improvements on mission range and noise levels was determined. This engine design was then compared with current existing high-technology core engines in order to define a subscale testbed configuration that simulated many of the critical technology features of the product/study VCE. Detailed preliminary program plans were then developed for the design, fabrication, and static test of the selected testbed engine configuration. These pians included estimated costs and schedules for the detail design. fabrication and test of the testbed engine and the definition of a tec. program, test plan, schedule, instrumentation, and test stand raquirements.

N79-13050°# Pratt and Whitney Aircraft Group, East Hartford, Conn Commercial Products Div

ANALYTICAL EVALUATION OF THE IMPACT OF BROAD SPECIFICATION FUELS ON HIGH BYPASS TURBOFAN ENGINE COMBUSTORS Final Report

R. P. Lohmann, E. J. Szetela, and A. Vranos Dec. 1978 161 p. refs

(Contract NAS3-20802)

PWA-5565-15) NASA-CR-159454;

NTIS

HC A08/MF A01 CSCL 21E

The impact of the use of broad specification fuels on the design, performance durability, emissions and operational characteristics of combustors for commercial aircraft gas turbine engines was assessed. Single stage, vorbix and lean premixed prevaporized combustors, in the JT9D and an advanced energy efficient engine cycle were evaluated when operating on Jet A and ERBS (Experimental Referee Broad Specification) fuels. Design modifications, based on criteria evolved from a literature survey, were introduced and their effectiveness at offsetting projected deficiencies resulting from the use of ERBS was estimated. The results indicate that the use of a broad specification fuel such as ERBS, will necessitate significant technology improvements and redesign if deteriorated performance, durability and emissions are to be avoided. Higher radiant heat loads are projected to seriously compromise liner life while the reduced thermal stability of ERBS will require revisions to the engine-airframe fuel system to reduce the thermal stress on the fuel. Smoke and emissions output are projected to increase with the use of broad specification fuels. While the basic geometry of the single stage and vorbix combustors are compatible with the use of ERBS, extensive redesign of the front end of the lean premixed prevaporized burner will be required to achieve satisfactory operation and optimum emissions G.G.

N79 15053° # General Electric Co., Evendale, Ohio Engine Business Group

ANALYSIS AND PRELIMINARY DESIGN OF AN OPTICAL DIGITAL TIP CLEARANCE SENSOR FOR PROPULSION CONTROL

G L Poppel Sep 1978 28 p (Contract NAS3-21006)

R78AEG518) INASA-CR-159434

Avail NTIS

HC A03/MF A01 CSCL 21E

Following the generation of several concepts for palsive. digital compatible, optical sensors for propulsion control systems. a tip clearance sensor was chosen for further analysis and preliminary design. Emphasis was placed on application to the TF34 engine compressor section. Laboratory experiments ivere performed to investigate several optical aspects of the concept Preliminary design included an assessment of all sensor elements and recommendations for development programs. Quantitative predictions were made of sensor performance. A test plan was written to demonstrate sensor feasibility and that the performance goals can be met. A continuing experimental and design effort was suggested. Author

N79-16850°# Pratt and Whitney Aircraft, East Hartford, Conn. ENERGY EFFICIENT ENGINE: PROPULSION SYSTEM-AIRCRAFT INTEGRATION EVALUATION Topicel Report, Mar. 1978 - Sep. 1978

R. E. Owens Mar. 1979 311 p refs

(Contract NAS3-20646)

PWA-5594-48) NTIS (NASA-CR-159488; Avail:

HC A14/MF A01 CSCL 21E

Flight performance and operating economics of future commercial transports utilizing the energy efficient engine were assessed as well as the probability of meeting NASA's goals for TSFC, DOC, noise, and emissions. Results of the initial propulsion systems aircraft integration evaluation presented include estimates of engine performance, predictions of fuel burns, operating costs of the flight propulsion system installed in seven selected advanced study commercial transports, estimates of noise and emissions, considerations of thrust growth, and the achievement-probability analysis.

N79-16853\*# United Technologies Research Center, East Hartford, Conn.

STUDY OF MEAN- AND TURBULENT-VELOCITY FIELDS IN A LARGE-SCALE TURBINE-VANE PASSAGE Final Report Douglas A. Bailey Feb. 1979 123 p refs

(Contract NAS3-19752)

(NASA-CR-3067) Avail: NTIS HC AGE/MF A01 CSCL 21E Laser-Doppler velocimetry, and to a lesser extent hot-wire anemometry, were employed to measure three components of the mean velocity and the six turbulant stresses at four planes within the turbine inlet-guide-vane passage. One variation in the turbulent inlet boundary layer thickness and one variation in the blade aspect ratio (span/axial chord) were studied. A longitudinal vortex (passage vortex) was clearly identified in the exit plane of the passage for the three test cases. The maximum turbulence intensities within the longitudinal vortex were found to be on the order of 2 to 4 percent, with large regions appearing nonturbulent. Because a turbulent wall boundary layer was the source of vorticity that produced the passage vortex, these low turbulence levels were not anticipated. For the three test cases studied, the lateral velocity field extended significantly beyond the region of the longitudinal velocity defect. Changing the inlet boundary layer thickness produced a difference in the location. the strength, and the extent of the passage vortex. Changing the aspect ratio of the blade passage had a measurable but less significant effect. The experiment was performed in a 210 mm pitch, 272 mm axial chord model in low speed wind tunnel at an inlet Mach number of 0.07. ARH

N79-17857\*# Pratt and Whitney Aircraft Group, West Palm Beach, Fla Government Products Div

DESIGN, FABRICATION AND SPIN TESTING OF CERAMIC BLADE METAL DISK ATTACHMENT Final Report

Avail

Glenn Calvert Feb 1979 152 p

(Contract NAS3-19715)

FR-10179) (NASA-CR-159532

HC A08/MF A01 CSCL 21E

A ceramic turbine blade metal disk attachment was designed for small, non-man-rated turbine engine applications. The selected design consisted of a hot pressed silicon nitride blade having a skewed dovetail attachment with a compliant interlayer between the disk and the blade. Two-dimensional and three-dimensional analyses predicted that life goals could be achieved, considering both NDE limitations and crack growth rates for the ceramic material Twenty ceramic blades were fabricated to closely held manufacturing tolerances. New fracture mechanics data at elevated temperature are presented SES

N79-17858\*# Hamilton Standard, Windsor Locks, Conn. INTERACTIVE MULTI MODE BLADE IMPACT ANALYSIS Final Report, Jan. 1976 - Aug. 1977 and Feb. 1978 - Aug. 1978

A Alexander and R W Cornell Aug 1978 301 p refs (Contract NAS3 20091)

(NASA-CR-159462) Avail NTIS HC A16/MF A01 CSCL

The theoretical methodology used in developing an analysis for the response of turbine engine fan blades subjected to soft-body (bird) in pacts is reported, and the computer program developed using this methodology as its basis is described. This computer program is an outgrowth of two programs that were previously developed for the purpose of studying problems of a similar nature (a 3-mode beam impact analysis and a multi-mode beam impact analysis). The present program utilizes an improved missile model that is interactively coupled with blade motion which is more consistent with actual observations I: takes into account local deformation at the impact area, blade camber effects, and the spreading of the impacted missile mass on the blade surface In addition, it accommodates plate-type mode shapes. The analysis capability in this computer program represents a significant improvement in the development of the methodology for evaluating potential fan blade materials and designs with regard to foreign object impact resistance

N79-18976\* Shaker Research Corp., Ballston Lake, N. Y. TURBOJET BLADE VIBRATION DATA ACQUISITION DESIGN AND FEASIBILITY TESTING Final Report

J. L. Frarey, N. J. Petersen (Amherst Systems), and D. A. Hess Nov. 1978 72 p

NTIS

(Contract NAS3-21.715)

SRC-78-TR-36) (NASA-CR-159505: Avail

HC A04/MF A01 CSCL 21E

A turbojet blade vibration data acquisition system was designed to allow the measurement of blade vibration. The data acquisition system utilizing 96 microprocessors to gather data from optical probes, store, sort and transmit to the central computer is described. Areas of high technical risk were identified and a two-microprocessor system was breadboarded and tested to investigate these areas. Results show that the system was feasible and that low technical risk would be involved in proceeding with the complete system fabrication. SES

N79-18977\* Naval Air Propulsion Test Center, Trenton, N.J. NOTOR FRAGMENT PROTECTION PROGRAM: STATIS-TICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN US COMMERCIAL AVIATION DURING 1976 Final Report, 1975 - 1976

R A DeLucia and J T. Salvino Jul. 1978 30 p. (NASA Order C-41581-B)

(NASA-CR-159474. NAPC-PE-9) NTIS HC A03/MF A01 CSCL 21E

Statistical information relating to the number of gas turbine engine rotor failures which occurred during 1976 in commercial aviation service use is presented. The predominant failure involved blade fragments, 88 percent of which were contained. Although fewer rotor rim, disk, and seal failures occurred, all were uncontained Sixty-seven percent of the 186 rotor failures occurred during the takeoff and climb stages of flight.

N79-18978\*# General Electric Co., Philadelphia, Pa CONTAINMENT OF COMPOSITE FAN BLADES Quarterly Progress Report, 1 Apr. - 30 Jun. 1977 A. P. Coppe and C. L. Stotler 1977 15 p

(Contract NAS3-20118)

(NASA-CR-158168: QPR-4: R77AEG 450) Avail NTIS HC A02/MF A01 CSCL 21E

The development of containment concepts for use with large composite fan blades, taking into account the frangible nature of composite blades is considered. Aspects of the development program include: (1) an analysis to predict the interaction between a failed fan blade and the blade containment structure; (2) scaling factors to allow impact testing using subscale containment rings

and simulated blades; (3) the design and fabrication of containment systems for further evaluation in a rotating rig test facility; (4) evaluate the test data against the analytically predicted results; and (5) determine overall systems weights and design characteristics of a composite fan stage installation and compare to the requirements of an equivalent titanium fan blade system. Progress in the blade impact penetration tests and the design and fabrication of blade containment systems is reported.

N79-20116\*# Pratt and Whitney Aircraft Group, East Hartford, Commercial Products Div

JT8D AND JT9D JET ENGINE PERFORMANCE IMPROVE-MEHT PROGRAM. TASK 1: FEASIBILITY ANALYSIS Final Report, Feb. - Dec. 1977

W. O. Gaffin and D. E. Webb Apr. 1979 227 p refs

(Contract NAS3-20630)

PWA-5518-38) (NASA-CR-159449; NTIS

HC A11/MF A01 CSCL 21E

JT8D and JT9D component performance improvement concepts which have a high probability of incorporation into production engines were indentified and ranked. An evaluation method based on airline payback period was developed for the purpose of identifying the most promising concepts. The method used available test data and analytical models along with conceptual/preliminary designs to predict the performance improvements, weight, installation characteristics, cost for new production and retrofit, maintenance cost, and qualitative characteristics of candidate concepts. These results were used to arrive at the concept payback period, which is the time required for an airline to recover the investment cost of concept implementation. GV

N79-20117°# General Electric Co., Evendale, Ohio, Aircraft Engine Group

THEORY OF LOW FREQUENCY NOISE TRANSMISSION

THROUGH TURBINES Final Report
R. K. Matta and R. Mani Mar. 1979 153 p refs

(Contract NAS3-20027)

(NASA-CR-159457; R77AEG570) Avail: HC A08/MF A01 CSCL 21E

Improvements of the existing theory of low frequency noise transmission through turbines and development of a working prediction tool are described. The existing actuator-disk model and a new finite-chord model were utilized in an analytical study. The interactive effect of adjacent blade rows, higher order spinning modes, blade-passage shocks, and duct area variations were considered separately. The improved theory was validated using the data acquired in an earlier NASA program. Computer programs incorporating the improved theory were produced for transmission loss prediction purposes. The programs were exercised parametrically and charts constructed to define approximately the low frequency noise transfer through turbines. The loss through the exhaust nozzle and flow(s) was also

N79-21073°# Detroit Die:el Allison, Indianapolis, Ind STUDY OF AN ADVANCED GENERAL AVIATION TURBINE ENGINE (GATE) Final Paport

J. C. Gill, F. R. Short, D. V. Staton, B. A. Zolezzi, C. E. Curry. M. J. Ore....... J. M. Vaught, and J. M. Humphrey 10 Apr 1979 147 p refs

(Contract NAS3-20756) DDA-EDR-9528) NTIS Avail (NASA-CR-159558.

HC A07/MF A01 CSCL 21E

The best technology program for a small, economically viable gas turbine engine applicable to the general aviation helicopter and aircraft market for 1985-1990 was studied Turboshaft and turboprop engines in the 112 to 746 kW (150 to 1000 hp) range and turbofan engines up to 6672 N (1500 lbf) thrust were considered A good market for new turbine engines was predicted for 1988 providing aircraft are designed to capitalize on the advantages of the turbine engine. Parametric engine families were defined in terms of design and off-design performance. mass, and cost. These were evaluated in aircraft design

missions selected to represent important market segments for fixed and rotary-wing applications. Payoff parameters influenced by engine cycle and configuration changes were aircraft gross mass, acquisition cost, total cost of ownership, and cash flow. Significant advantage over a current technology, small gas turbine engines was found especially in cost of ownership and fuel economy for airframes incorporating an air-cooled high-pressure ratio engine. A power class of 373 kW (500 hp) was recommended as the next frontier for technology advance where large improvements in fuel economy and engine mass appear possible through component research and development.

N79-21074°# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group

CF6 JET ENGINE PERFORMANCE IMPROVEMENT PRO-GRAM. TASK 1: FEASIBILITY ANALYSIS Final Report W. A. Fasching Mar. 1979 370 p refs

NTIS

NTIS

Avail:

Avail.

(Contract NAS3-20629)

(NASA-CR-159450: R79AEG295)

HC A13/MF A01 CSCL 21E

Technical and economic engine improvement concepts selected for subsequent development include: (1) fan improvement; (2) short core exhaust; (3) HP turbine aerodynamic improvement; (4) HP turbine roundness control; (5) HP turbine active clearance control; and (6) cabin air recirculation. The fuel savings for the selected engine modification concepts for the CF6 fleet are estimated. SES

N7S-21075\*# Ford Motor Co., Dearborn, Mich.

**EVALUATION OF CERAMICS FOR STATOR APPLICATION:** GAS TURBINE ENGINE REPORT Progress Report, 1 Feb. 1978 - 31 Jul. 1978

W. Trela and P. H. Havstad Nov. 1978 36 p refs Prepared for DOF

(Contract DEN-3-00019)

NTIS

(NASA-CR-159533: DOE/NASA/0019-78/1) Avail: NTIS

HC A03/MF A01 CSCL 21E

Current ceramic materials, component fabrication processes, and reliability prediction capability for ceramic stators in an automotive gas turbine engine environment are assessed. Simulated engine duty cycle testing of stators conducted at temperatures up to 1093 C is discussed. Materials evaluated are SiC and Si3N4 fabricated from two near-net-shape processes: slip casting and injection molding. Stators for durability cycle evaluation and test specimens for material property characterization, and reliability prediction model prepared to predict stator performance in the simulated engine environment are considered. The status and description of the work performed for the reliability prediction modeling, stator fabrication, material property characterization, and ceramic stator evaluation efforts are reported J.M.S.

N79-21076°# Pratt and Whitney Aircraft Group, East Hartford,

JTBD REVISED HIGH-PRESSURE TURBINE COOLING AND OTHER OUTER AIR SEAL PROGRAM

W. O. Gaffin 20 Mar. 1979 59 p refs (Contract NAS3-20630)

(NASA-CR-159551; PWA-5515-77)

HC A04/MF A01 CSCL 21E

The JT8D high pressure turbine was revised to reduce leakage between the blade tip shrouds and the outer air seal, and engine testing was performed to determine the effect on performance. The addition of a second knife-edge on the blade tip shroud, the extension of the honeycomb seal land to cover the added knife-edge and an existing spoiler on the shroud, and a material substitution in the seal support ring to improve tharmal growth characteristics are included. A relocation of the blade cooling air discharge to insure adequate cooling flow is required. Significant specific fuel consumption and exhaust gas temperature improvements were demonstrated with the revised turbine in sea level and simulated altitude engine tests. Inspection of the revised seal hardware after these tests showed no unusual wear or degradation. SES

N79-23084°# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div. VARIABLE CYCLE ENGINE TECHNOLOGY PROGRAM PLANNING AND DEFINITION STUDY Finel Report J. S. Wastmoreland and A. M. Stern Sep. 1978 89 p (Contract NAS3-20811) NASA-CR-159539. PWA-5581-12) NTIS HC A05/MF A01 CSCL 21E

The variable stream control engine, VSCE-502B, was selected as the base engine, with the inverted flow angine concept selected as a backup Critical component technologies were identified. and technology programs were formulated. Several engine configurations were defined on a preliminary basis to serve as demonstration vehicles for the various technologies. The different configurations present compromises in cost, technical risk, and technology return. Plans for possible variably cycle engine technology programs were formulated by synthesizing the technology requirements with the different demonstrator configurations.

N79-23085°# Pratt and Whitney Aircraft Group, East Hartford,

STUDY OF BLADE ASPECT RATIO ON A COMPRESSOR FRONT STAGE AERODYNAMIC AND MECHANICAL DESIGN REPORT

G. D. Burger, C. Lee, and D. W. Snow Mar. 1979 84 p refs (Contract NAS3-20809)

PWA-5583-25) NASA-CR-159555.

HC A05/MF AU1 CSCL 21E

A singly stage compressor was designed with the intent of demonstrating that, for a tip speed and hub-tip ratio typical of an advanced core compressor front stage, the use of low aspect ratio can permit high levels of blade loading to be achieved at an acceptable level of afficiency. The design pressure ratio is 1.8 at an adiabatic efficiency of 88.5 percent. Both rotor and stator have multiple-circular-arc airfoil sections. Variable IGV and stator vanes permit low speed matching adjustments. The design incorporates an inlet duct representative of an engine transition duct between fan and high pressure compressor.

N79-23970°# General Electric Co., Cincinneti, Ohio. Aircraft Engine Group

FABRICATION OF J79 BORON/ALUMINUM COMPRESSOR BLADES Fina! Report, Apr. 1975 - Jun. 1978

J. W. Brantley and R. G. Stabrylla May 1979 74 p refs (Contract NAS3-18943)

(NASA-CR-159566; R79AEG388) HC A04/MF A01 CSCL 21E

A total of 81 boron/aluminum first stage compressor blades were developed. The processing of the blades and the series designs established for various types of blade tests are described

N79-25017\*# Williams Research Corp., Walled Lake Mich ADVANCED GENERAL AVIATION TURBINE ENGINE (GATE) CONCEPTS Final Report

E. J. Lays and G. L. Murray 26 Jun. 1979 183 p. refs. (Contract NAS3 20758)

(NASA-CR-159603. WRC-78-113-15) NTIS HC A09/MF A01 C3CL 21E

Concepts are discussed that project turbine engine cost savings through use of geometrically constrained components designed for low rotational speeds and low stress to permit manufacturing economies. Aerodynamic development of geometrically constrained components is recommended to maximize component efficiency. Conceptual engines, airplane applications, airplane performance, engine cost, and engine related life cycle costs are presented. The powerplants proposed offer encouragement with respect to fuel efficiency and life cycle costs, and make possible remarkable airplane performance gains MMM

N79-25018\*# Solar Turbines International, San Diego, Calif. INTERNALLY COATED AIR-COOLED GAS TURBINE BLADING Final Report, Aug. 1977 - Dec. 1978 L Hsu, W. G. Stevens, and A. R. Stetson Mar. 1979 102 p

(NASA-CR-159574. SR79-R-4655-15) Avail NTIS HC A06/MF A01 CSCL 21E

Ten candidate modified nickel-aluminide coatings were developed using the slip pack process. These coatings contain additives such as silicon, chromium and columbium in a nickel-aluminum coating matrix with directionally solidified MAR-M200 - Hf as the substrate alloy. Following a series of screening tests which included strain tolerance, dynamic oxidation and hot corrosion testing, the Ni-19A1-1Cb (nominal composition) co-the was selected for application to the internal passages of st-stage turbine blades. Process development results e that a dry pack process is suitable for internal coating cation resulting in 18 percent or less reduction in air flow. Coating uniformity, based on coated air-cooled blades, was within + or - 20 percent. Test results show that the presence of additives (silicon, chromium or columbium) appeared to improve significantly the ductility of the NiA1 matrix. However, the environmental resistance of these modified nickel-aluminides were generally inferior to the simple aluminides. A.R.H.

N79-25020°# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group

DESIGN STUDY AND PERFORMANCE ANALYSIS OF A HIGH-SPEED MULTISTAGE VARIABLE-GEOMETRY FAN FOR A VARIABLE CYCLE ENGINE Final Report

T. J. Sullivan and D. E. Parker Mar 1979 228 p. refs (Contract NAS3-20041, R79AEG288)

(NASA-CR-159545) Avail NTIS HC A11/MF A01 CSCL

A design technology study was performed to identify a high speed, multistage, variable geometry fan configuration capable of achieving wide flow modulation with near optimum efficiency at the important operating condition. A parametric screening study of the front and rear block fans was conducted in which the influence of major fan design features on weight and efficiency was determined. Key design parameters were varied systematically to determine the fan configuration most suited for a double bypass, variable cycle engine. Two and three stage fans were considered for the front block. A single stage, core driven fan was studied for the rear block. Variable geometry concepts were evaluated to provide near optimum off design performance. A detailed aerodynamic design and a preliminary mechanical design were carried out for the selected fan configuration. Performance predictions were made for the front and rear block fans. Author

N79-26065\*# Pratt and Whitney Aircraft Group, East Hartford. Conn

ROTOR REDESIGN FOR A HIGHLY LOADED 1800 FT/SEC TIP SPEED FAN. 1: AERODYNAMIC AND MECHANICAL DESIGN REPORT

J. M. Norton, U. Tari, and R. M. Weber. Apr. 1979. 104 p.

(Contract NAS3-20591)

(NASA-CR-159596; PWA-5523-42) Avail: NTIS HC A06/MF A01 CSCL 21E

A quasi three dimensional design system and multiple-circulararc airfoil sections were used to design a fan rotor. An axisymmetric intrablade flow field calculation modeled the shroud of an isolated splitter and radial distribution. The structural analysis indicates that the design is satisfactory for evaluation of aerodynamic performance of the fan stage in a test facility.

1 × 12 × 1 × 2 1 × 1 × 1

N79-30185\*# Pratt and Whitney Aircraft Group, East Hartford, Conn

AERODYNAMIC AND ACOUSTIC INVESTIGATION OF INVERTED VELOCITY PROFILE COANNULAR & THAUST NOZZLE MODELS AND DEVELOPMENT OF AERODYNAMIC AND ACQUSTIC PREDICTION PROCEDURES, COMPRE-HENSIVE DATA REPORT, VOLUME 1

Richard S. Larson, Douglas P. Nelson, and Bradley S. Stevens Jun 1979 312 p 2 Vol.

(Contract NAS3-20061)

(NASA-CR-159515: PWA-5550-16-Vol-1) Avail: NTIS HC A14/MF A01 CSCL 21E

The experimental data necessary to establish aerodynamic and acoustic prediction systems for coannular exhaust nozzles with inverted velocity profiles are presented in graphical form.

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N79-30186\*# Pratt and Whitney Aircraft Group, East Hartford,

AERODYNAMIC AND ACOUSTIC INVESTIGATION OF INVERTED VELOCITY PROFILE COANNULAR EXHAUST NOZZLE MODELS AND DEVELOPMENT OF AERODYNAMIC AND ACCUISTIC PREDICTION PROCEDURES, COMPRE-HENSIVE DATA REPORT, VOLUME 2

Richard S. Larson, Douglas P. Nelson, and Bradley S. Stevens Jun 1979 225 p. refs. (Contract NAS3-20061)

(NASA-CR-159516, PWA-5550-17-Vol-2) HC A10/MF A01 CSCL 21E NTIS

The experimental data necessary to establish aerodynamic and acoustic prediction systems for coannular exhaust nozzles with inverted velocity profiles are presented in tabular form. The acoustic data are corrected to a 'theoretical day' and scaled to RES full engine size.

N79-30189\*# Pratt and Whitney Aircraft Group, East Hartford, Conn Commercial Products Div

ENERGY EFFICIENT ENGINE FLIGHT PROPULSION SYSTEM PRELIMINARY ANALYSIS AND DESIGN REPORT Progress Report, Mar. 1978 - Feb. 1979

W B Gardner Apr 1979 480 p refs

(Contract NAS3-20646)

PWA-5594-49) (NASA-CR-159487.

HC A21/MF A01 CSCL 21E

A flight propulsion system preliminary design was established that meets the program goals of at least a 12 percent reduction in thrust specific fuel consumption, at least a five percent reduction in direct operating cost, and one-half the performance deterioration rate of the most efficient current commercial engines. The engine provides a high probability of meeting the 1978 noise rule goal. Smoke and gaseous emissions defined by the EPA proposed standards for engines newly certified after 1 January 1981 are

met with the exception of NOx, despite incorporation of all known NOx reduction technology.

N79-31207\* # General Electric Co., Cincinnati, Ohio. EXPERIMENTAL CLEAN COMBUSTOR PROGRAM (ECCP). PHASE 3 Final Report

C C Gleason and D W Bahr 1 Jun 1979 201 p refn (Contract NAS3-19736)

(NASA-CR-135384. R79AEG410)

HC A10/MF A01 CSCL 21E

A double annular advanced technology combustor with low pollutant emission levels was evaluated in a series of CF6-50 engine tests. Engine lightoff was readily obtained and no difficulties were encountered with combustor staging Engine acceleration and deceleration were smooth, responsive and essentially the same as those obtainable with the CF6-50 combustor. The emission reductions obtained in carbon monoxide hydrocarbons. and nitrogen oxide levels were 55 95, and 30 percent. respectively, at an idle power setting of 3.3 percent of takeoff power on an EPA parameter basis. Acceptable smoke levels were also obtained. The exit temperature distribution of the combustor was found to be its major performance deficiency. In all other important combustion system performance aspects, the combustor was found to be generally satisfactory

N79-31212\*# United Technologies Corp., East Hartford, Conn. AERODYNAMIC AND ACOUSTIC INVESTIGATION OF INVERTED VELOCITY PROFILE COANNULAR EXHAUST NOZZLE MODELS AND DEVELOPMENT OF AERODYNAMIC AND ACOUSTIC PREDICTION PROCEDURES Final Report

Richard S. Larson, Douglas P. Nelson, and Bradley S. Stevens Washington NASA Aug. 1979 223 p refs (Contract NAS3-20061)

NASA-CR-3168: PWA-5550-8) NTIS HC A10/MF A01 CSCL 21E

Five co-annular nozzle models, covering a systematic variation of nozzle geometry, were tested statically over a range of exhaust conditions including inverted velocity profile (IVP) (fan to primary stream velocity ratio > 1) and non IVP profiles. Fan nozzle pressure ratio (FNPR) was varied from 1.3 to 4.1 at primary nozzle pressure ratios (PNPR) of 1.53 and 2.0 Fan stream temperatures of 700 K (1260 deg R) and 1089 K(1960 deg R) were tested with primary stream temperatures of 700 K (1260 deg R). 811 K (1460 deg R), and 1089 K (1960 deg R). At fan and primary stream velocities of 610 and 427 m/sec (2000 and 1400 ft/sec), respectively, increasing fan radius ratio from 0.69 to 0.83 reduced peak perceived noise level (PNL) 3 dB, and an increase in primary radius ratio from 0 to 0.81 (fan radius ratio constant at 0.83) reduced peak PNL an additional 1.0 dB. There were no noise reductions at a fan stream velocity of 853 m/sec (2800 ft/sec). Increasing fan radius ratio from 0.69 to 0.83 reduced nozzle thrust coefficient 1.2 to 1.5% at a PNPR of 153, and 17 to 20% at a PNPR of 20. The developed acoustic prediction procedure collapsed the existing data with standard deviation varying from + or - 8 dB to + or - 7 dB The aerodynamic performance prediction procedure collapsad thrust coefficient measurements to within + or - 004 at a FNPR of 40 and a PNPR of 2.0. Author

N79-32211\*# Pratt and Whitney Aircraft Group, East Hartford, Conn Commercial Products Div

LEAN, PREMIXED, PREVAPORIZED FUEL COMBUSTOR CONCEPTUAL DESIGN STUDY Final Report

A J. Fiorentino, W. Greene, and J. Kim. Washington. NASA Aug 1975 63 p refs

(Contract NAS3-21256)

(NASA-CR-159647: PWA-5626-12) NTIS HC A04/MF A01 CSCL 21E

Four combustor concepts, designed for the energy efficient engine, utilize variable geometry or other flow modulation techniques to control the equivalence ratio of the initial burning zone. Lean conditions are maintained at high power to control oxides of nitrogen while near stoichometric conditions are maintained at low power for low CO and THC emissions. Each concept was analyzed and ranked for its potential in meeting the goals of the program. Although the primary goal of the program is a low level of nitric oxide emissions at stratospheric cruise conditions, both the ground level EPA emission standards and combustor performance and operational requirements typical of advanced subsonic aircraft engines are retained as goals as well. Based on the analytical projections made, two of the concepts offer the potential of achieving the emission goals, however, the projected operational characteristics and reliability of any concept to perform satisfactorily over an entire aircraft flight envelope would require extensive experimental substantiation before engine adaptation can be considered. A.R.H.

N79-32212°# Cincinnati Univ. Ohio. Dept of Aerospace Engineering and Applied Mechanics

FLOW IN NONROTATING PASSAGES OF RADIAL INFLOW TURBINES

E Baskharone, A Hamed, and W Tabakoff Sep. 1979 104 p. refs

(Grant NsG-3066)

(NAS R-159679) Avail NTIS HC A06/MF A01 CSCL

ing analysis of irrotational incompressible flow field in the stator unit of a radial inflow turbine is presented. The solution in the combined scroil-nozzle assembly is complicated by the domain geometry and by its multiconnectivity. This model is

necessary, however, in order to provide a better understanding of the mutual interaction effects of these two components on the flow field. The finite element method is used in the solution which is limited to the two dimensional case. A substructuring technique is adopted in the computational procedure and results in considerable savings in both computer time and core storage requirements. The results are presented for the flow velocity magnitude and direction in the scroll and through the various nozzles, for two nozzle blade geometries. In addition, the mass flow rates in the different nozzles are computed and their deviations from the mean value determined.

A79-26925 \* # Reduction of roto:-turbulence interaction noise in static fan noise testing, R. A. Kantula and R. E. Warren (GE Corporate Research and Development Center, Schenectady, N.Y.), American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Pager 79-0656. 18 p. 22 refs. Contract No. NAS3-17853.

Three effective inlet cleanup methods are described. A flared reverse cone inlet is used to eliminate wakes from the fan casings and/or probe supports. Boundary layer suction is employed ahead of the fan rotor and on the outer flare of the cone to reduce the boundary layer turbulence and remove any residual wakes. To reduce the midstream turbulent intensity and length scales, a turbulence control structure is used which is constructed with both a layer of honeycomb and a fine mesh screen. The effects of these cleanup methods are quantified by measuring the far-field noise in an anechoic chamber, using a high-speed 20-in.-diam fan of the current high passband type. The changes in the turbulent field impinging on this rotor are quantified by mapping the streamwise and transverse turbulent properties (spectra, intensity and length scale) with crossed hot film probes. It is convincingly shown that it is possible to clean up the inlet flow of a static fan noise test facility to a point where the static acoustic data simulate flight data.

A79-36737 \* Concepts for reducing exhaust emissions and fuel consumption of the aircraft piston engine. B. J. Rezy, K. J. Stuckas, J. R. Tucker, and J. E. Meyers (Teledyne Continental Motors, Mobile, Ala.). Society of Automotive Engineers, Business Aircraft Meeting and Exposition, Wichita, Kan., Apr. 3-6, 1979, Paper 790605. 35 p. 23 refs. Research supported by the Teledyne Continental Motors; Contract No. NAS3-19755.

A study was made to reduce exhaust emissions and fuel consumpt in of a general aviation aircraft piston engine by applying known technology. Fourteen promising concepts such as stratified charge combustion chambers, cooling cylinder head improvements, and ignition system changes were evaluated for emission reduction and cost effectiveness. A combination of three concepts, improved fuel injection system, improved cylinder head with exhaust port liners and exhaust air injection was projected as the most cost effective and safe means of meeting the EPA standards for CO, HC and NO. The fuel economy improvement of 4.6% over a typical single engine aircraft flight profile does not though justify the added cost of the three concepts, and significant reductions in fuel consumption must be applied to the cruise mode where most of the fuel is used. The use of exhaust air injection in combination with exhaust port liners reduces exhaust valve stem temperatures which can result in longer valve guide life. The use of exhaust port liners alone can reduce engine cooling air requirements by 11% which is the equivalent of a 1.5% increase in propulsive power. The EPA standards for CO, HC and NO can be met in the IO-520 engine using air injection alone or the Simmonds improved fuel injection system. AT

A79-36749 \* A review of Curtiss-Wright rotary engine developments with respect to general aviation potential. C. Jones (Curtiss-Wright Corp., Wood-Ridge, N.J.). Society of Automotive Engineers, Business Aircraft Meeting and Exposition, Wichita, Kan., Apr. 3-6, 1979, Paper 790621. 23 p. 21 refs. Contracts No. NAS3-20030. No. NAS3-20808.

Aviation related rotary (Wankel-type) engine tests, possible growth directions and relevant developments at Curtiss-Wright have been reviewed. Automotive rotary engines including stratified charge are described and flight test results of rotary aircraft engines are presented. The current 300 HP engine prototype shows basic durability and competitive performance potential. Recent parallel developments have separately confirmed the geometric advantages of the rotary engine for direct injected unthrottled stratified charge. Specific fuel consumption equal to or better than pre- or swirl-chamber diesels, low emission and multi-fuel capability have been shown by rig tests of similar rotary engine.

A.T.

A79-39035 \* # Lean stability augmentation for premixing, prevaporizing combustors. J. B. McVey and J. B. Kennedy (United Technologies Research Center, East Hartford, Conn.). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1319. 12 p. 5 refs. Contract No. \*IAS3-20804.

An experimental program was conducted to investigate techniques for improving the lean combustion limits of premixing, prevaporizing combustors applicable to gas turbine engine main burners. Augmented flameholders employing recessed perforated plates, catalyzed tube bundles, and configurations in which pilot fuel was injected into the wakes of V-gutters or perforated plates were designed and tested. Stable operation of the piloted designs was achieved at equivalence ratios as low as 0.25; NOx emissions of less than 1.0 g/kg at simulated turbine engine cruise conditions were obtained. A piloted perforated plate employing four percent pilot fuel flow produced the best performance while meeting severe NOx constraints. (Author)

A79-40483 \* # Causes of high pressure compressor deterioration in service. J. H. Richardson, G. P. Sallee, and F. K. Smakula (United Technologies Corp., Prat\* and Whitney Aircraft Group, East Harttord, Conn.). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1234.

The high mechanical reliability and low deterioration rate of the JT9D high-pressi - compressor results in long utilization without exceeding engine operational limits. The increasing cost and decreasing supply of fuel have focused attention on the fuel burned implications of such high time use without refurbishment. The paper presents the results of JT9D high pressure compressor studies. The mechanical deterioration of the JT9D high-pressure compressor gaspath parts versus increasing service usage, documented from inspection of service parts, is presented and discussed including changes in airfoil roughness, blade length, airfoil contour and outer air seal trench characteristics. An estimate of the performance loss versus usage is related to each type of damage. The combined estimated high-pressure compressor performance loss for all mechanisms determined from part inspection is compared to historical engine test data to establish the validity of the predicted loss levels. The effect of cold section refurbishment on engine fuel consumption recovery and the results of an optimization study to determine the appropriate interval for high pressure compressor refurbishment are (Author) also reported.

A79-40759 \* # Progress on Variable Cycle Engines. J. S. Westmoreland, R. A. Howlett, and R. P. Lohmann (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1312. 11 p. 9 refs. Contracts No. NAS3-20061. No. NAS3-20602. No. NAS3-20048.

Progress in the development and fixture requirements of the Variable Stream Control Engine (VSCE) are presented. The two most critical components of this advanced system for future supersonic transports, the high fintermance duct burner for thrust augmentation, and the low jet coannular nozzle were studied. Nozzle model tests substantiated the jet noise benefit associated with the unique

velocity profile possible with a coannular nozzle system on a VSCE. Additional nozzle model performance tests have established high thrust efficiency levels only at takeoff and supersonic cruisc for this nozzle system. An experimental program involving both isolated component and complete engine tests has been conducted for the high performance, low emissions duct burner with good results and large scale testing of these two components is being conducted using a F100 engine as the testbed for simulating the VSCE. Future work includes application of computer programs for supersonic flow fields to coannular nozzle geometries, further experimental testing with the duct burner segment rig, and the use of the Variable Cycle Engine (VCE) Testbed Program for evaluating the VSCE duct burner and coannular nozzle technologies.

## 08 AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

N79-28186\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PREDICTING DYNAMIC PERFORMANCE LIMITS FOR SERVOSYSTEMS WITH SATURATING NONLINEARITIES John A. Webb, Jr. and Richard A. Blech Jul. 1979 52 p refs (NASA-TP-1488; E-9903) Avail: NTIS HC AG4/MF A01 CSCL 01C

A generalized treatment for a system with a single saturating nonlinearity is presented and compared with frequency response plots obtained from an analog model of the system. Once the amplitude dynamics are predicted with the limit lines, an iterative technique is employed to dotarinine the system phase response. The saturation limit line technique is used in conjunction with velocity and acceleration limits to predict the performance of an electro-hydraulic servosystem containing a single-stage servovalve. Good agreement was obtained between predicted performance and experimental data.

N75-33210\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EFFECTS OF DIFFUSION FACTOR, ASPECT RATIO AND SOLIDITY ON OVERALL PERFORMANCE OF 14 COMPRESSOR MIDDLE STAGES

Werner R. Britsch, Walter M. Osborn, and Mark R. Laessig Washington Sep. 1979–148 p

(NASA-TP-1523; E-9943) Avail: NTIS HC A07/MF A01 CSCL

A series of high hub tip radius ratio compressor stages representative of the middle and latter stages of axial flow compressors the discussed. The effects of aspect ratio, diffusion factor, and solidity on rotor and stage performance are determined. Fourteen middle stages are tested to study the effects on performance of varying both diffusion through the rotor and stator blades and blade aspect ratio. The design parameters in the streamline analysis program, the blade geometry program, and the blade coordinate program are presented.

A.W.H.

A79-21296 \* # The NASA high pressure facility and turbine test rig. F. S. Stepka (NASA, Lewis Research Center, Turbine Cooling Section, Cleveland, Ohio). U.S. Navy and U.S. Air Force, Workshop on Cooling Problems in Aircraft Gas Turbines. Monterey, Calif., Sept. 27, 28, 1978, Paper. 16 p. Project SQUID.

NASA Lewis Relearch Center is presently constructing a test facility for developing turbine-cooling and combustor technology for future-generation aircraft gas-turbine engines. Prototype engine hardware will be investigated in this facility at gas-stream conditions up to 2480 K average turbine inlet tamperature and 4.14 million N/sq m turbine inlet pressure. The facility will have the unique features of fully automated control and data acquisition through the use of an integrated system of minicomputers and programmable controllers, which will result in more effective use of operating time and operators and will provide a built-in self-protection safety system. The facility turbine rig, and turbine-cooling test program are described. (Author)

A79-53750 \* # An overview of NASA research on positive displacement type general aviation engines. E. E. Kempke and E. A. Willis (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics Aircraft Systems and Technology. Meeting, New York, N.Y., Aug. 20-22, 1979, Paper 79-1824, 38 p. 12 refs.

The paper surveys the current status of the aviation positive displacement engine programs underway at the NASA Lewis Research Center. The program encompasses conventional, lightweight

diesel, and rotary combustion engines. Attention is given to topics such as current production type engine improvement, cooling drag reduction, fuel injection, and experimental and theoretical combustion studies. It is shown that the program's two major technical thrusts are directed toward lean operation of current production type spark ignition engines and advanced alternative engine concepts. Finally, an Otto cycle computer model is also covered.

M.E.P.

CFS JET ENGINE PERFORMANCE IMPROVEMENT PRO-GRAM. SHORT CORE EXHAUST NOZZLE PERFORMANCE IMPROVEMENT CONCEPT

W. A. Fasching Sep. 1979 113 p refs (Contract NAS3-20629)

(NASA-CR 159564) Avail: NTIS HC A06/MF A01 CSCL 21E

The short core exhaust Tozzle was evaluated in CF6-50 engine ground tests including performance, acoustic, and endurance tests. The test esuits verified the performance predictions from scale model tests. The short core exhaust nozzle provides an internal cruise sfo reduction of 0.9 percent without an increase in engine noise. The nozzle hardware successfully completed 1000 flight cycles of endurance testing without any signs of distress.

Author

## 09 RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

For related information see also 14 Ground Support Systems and Facilities (Space).

N79-21084° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HYPERVELOCITY GUN Patent

Franklin C. Ford (MB Assoc., San Ramon, Calif.) and Arthur J. Biehl, inventors (to NASA) Issued 21 Dec. 1985 3 p filed 7 Jun. 1962 Sponsored by NASA

(NASA-Case-XLE-03186-1; US-Patent-3,224,337;

US-Patent-Appl-SN-200770; US-Patent-Class-89-8) Avail: US Patent and Trademark Office CSCL 14B

A velocity amplifier system which uses both electric and chemical energy for projectile propulsion is provided in a compact hypervelocity gun suitable for laboratory use. A relatively heavy layer of a tamping material such as concrete enclose; a loop of an electrically conductive material. An explosive charge at least partially surrounding the loop is adapted to collapse the loop upon detonation of the charge. A source of electricity charges the loop through two leads, and an electric switch which is activated by the charge explosive charge, disconnects the leads from the source of electricity and short circuits them. An opening in the tamping material extends to the loop and forms a barrel. The loop, necked down in the opening, forms the sabot on which the projectile is located. When the loop is electrically charged and the explosive detonated, the loop is short circuited and collapsed thus building up a magnetic field which acts as a sabot catcher. The sabot is detached from the loop and the sabot and projectile are accelerated to hypervelocity.

Official Gazette of the U.S. Patent and Trademark Office

A79-32398 \* # Low-turbulence high-speed wind tunnel for the determination of cascade shock losses. J. A. Slovisky (Notre Dame, University, Notre Dame, Ind.), W. B. Roberts (Nielsen Engineering and Research, Inc., Mountain View, Calif.), and D. M. Sandercock (NASA, Lewis Research Center, Fan and Compressor Branch, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-129. 11 p. 23 refs. Members, \$1.50; nonmembers, \$3.00.

A low turbulence high-speed wind tunnel, using anti-turbulence screening and a 100:1 contraction ratio, has been found suitable for high-speed smoke flow visualization. The location and strength of normal, oblique, and curved shock waves generated by transonic or supersonic wind tunnel flow over airfoils or through axial compressor cascades is determined by combined shadowgraph and smokelines visualization techniques without the interference effects caused by intrusive probes. The Reynolds number based on chord varied between 50,000 and 1,000,000. Preliminary results are compared with the relevant theory and data gathered using a total pressure probe.

(Author)

N79-29189\* # Teledyne CAE, Toledo, Ohio.
ADVANCED GENERAL AVIATION TURBINE ENGINE (GATE) STUDY Final Report

R Smith and E. H. Benstein Jun 1979 150 p refs (Contract NAS3-20757)

(NASA-CR-159624; Yeledyne-CAE-1600) Avail NTIS HC A07/MF A01 CSCL 21E

The small engine technology requirements suitable for general aviation service in the 1987 to 1988 time frame were defined. The market analysis showed potential United States engines sales of 31.500 per year providing that the turbine engine sales price approaches current reciprocating engine prices. An optimum engine design was prepared for four categories of fixed wing aircraft and for rotary wing applications. A common core approach

was derived from the optimum engines that maximizes engine commonality over the power spectrum with a projected price competitive with reciprocating piston engines. The advanced technology features reduced engine cost, approximately 50 percent compared with current technology.

J.M.S.

N79-29191° 

General Electric Co., Evendale, Ohio. Aircraft Engine Group.

NASA CFS JET ENGINE DIAGNOSTICS PROGRAM: LONG-TERM CFS-SD LOW-PRESSURE TURBINE DETE-RIORATION

Jeffrey J. Smith Aug. 1979 116 p refs

(Contract NAS3-20631)

(NASA-CR-159618; R79AEG356)

HC A06/MF A01 CSCL 21E

Back-to-back performance tests were run on seven airline low pressure turbine fLPT) modules and four new CF6-6D modules. Back-to-back test cell runs, in which an airline LPT module was directly compared to a new production module, were included. The resulting change, measured in fuel burn, equaled the level

of LPT module deterioration. Three of the LPT modules were

Avail

NTIS

analytically inspected followed by a back-to-back test cell run to evaluate current refurbishment techniques.

Author

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### 12 ASTRONAUTICS (GENERAL)

For extraterrestrial exploration see 91 Lunar and Planetary Exploration.

N79-32232\* 

Mational Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

MASS DRIVERS. 3: ENGINEERING c37

William Arhold (Hampshire Coll.), Stuart Bowen, Steve Cohen, Kevin Fine (MIT), David Kaplan (Michigan Univ.), Margaret Kolm (Haverford Coil.), Henry Kolm (MIT), Jonathan Newman (Amherst Coll.), Gerard K. ONeill (Princeton Univ.), and William Snow (MIT) in NASA. Ames Res. Center Space Resources and Space Settlements 1979 p 119-157 refs (For primary document see N79-32225 23-12)

Avail: NTIS MF A01: SOD HC CSCL 131

The last of a series of three papers by the Mass-Driver Group of the 1977 Ames Summer Study is presented. It develops the engineering principles required to implement the basic mass-driver. Optimum component mass trade-offs are derived from a set of four input parameters, and the program used to design a lunar launcher. The mass optimization procedures is then incorporated into a more comprehensive mission optimization program called OPT-4, which evaluates an optimized mass-driver reaction engine and its performance in a range of specified missions. Finally, this paper discusses, to the extent that time permitted, certain peripheral problems, heating effects in buckets due to magnetic field ripple; an approximate derivation of guide force profiles; the mechanics of inserting and releasing payloads, the reaction mass orbits; and a proposed research and development plan for implementing mass drivers.

N79-20161\*# Princeton Combustion Lab., N. J.
DEFINITION OF SMOLDER EXPERIMENTS FOR SPACELAB
Progress Report, 18 Apr. - 20 Dec. 1978

M. Summerfield, N. A. Messina, and L. S. Ingram. Jan. 1979 81 p. refs

(Contract NAS3-21354)

(NASA-CR-159528; PCRL-FR-79-001) Avail: NTIS HC A05/MF A01 CSCL 22A

The feasibility of conducting experiments in space on smoldering combustion was studied to conceptually design specific smoldering experiments to be conducted in the Shuttle/Spacelab System. Design information for identified experiment critical components is provided. The analytical and experimental basis for conducting research on smoldering phenomena in space was established. Physical descriptions of the various competing processes pertaining to smoldering combustion were identified. The need for space research was defined based on limitations of existing knowledge and limitations of ground-based reduced-gravity experimental facilities.

### 13 ASTRODYNAMICS

Includes powered and free-flight trajectories; and orbit and launching dynamics.

N79-26101\*# Georgia Inst of Tech., Atlanta. Engineering Experiment Station.

MILLIMETER WAVE SATELLITE CONCEPTS. VOLUME 1: EXECUTIVE SUMMARY Report, Jun. 1976 - Jun. 1978

N. B. Hilsen, L. D. Holland, R. W. Wallace, D. L. Kelly, R. E. Thomas, J. J. Gallagher, and F. H. Vogler Jun. 1979

32 p. refs. 2. Vol.

(Contract NAS3-20110, Georgia Tech. Proj. A-1855) (NASA-CR-159504) Avail. NTIS HC A03/MF A01 CSCL 228

The objectives of the program were: (1) development of methodology based on the technical requirements of potential services that might be assigned to millimeter wave bands for identifying the viable and appropriate technologies for future NASA millimeter research and development programs, and (2) testing of this methodology with user applications and services. The scope of the program included the entire communications network, both ground and space subsystems. The reports include: (1) cost, weight, and performance models for the subsystems, (2) conceptual design for point-to-point and broadcast communications satellites. (3) analytic relationships between subsystem parameters and an overall link performance. (4) baseline conceptual systems. (5) sensitivity studies. (6) model adjustment analyses. (7) identification of critical technologies and their risks, (8) brief R&D program scenarios for the technologies judged to be moderate or extensive risks

N79-26102\*# Georgia Inst. of Tech., Atlanta. Engineering Experiment Station.

MILLIMETER WAVE SATELLITE CONCEPTS. VOLUME 2: TECHNICAL REPORT Report, Jun. 1976 - Jun. 1978

N. B. Hilsen, L. D. Holland, R. W. Wallace, D. L. Kelly, R. R. Thomas, and F. H. Vogler May 1979 40 p. refs 2. Vol. (Contract NAS3-20110. Georgia Tech. Proj. A-1855) (NASA-CR-159503) Avail. NYIS. HC A03/MF A01. CSCL.

Identification of technologies for millimeter satellite communication systems, and assessment of the relative risks of these technologies, were accomplished through subsystem modeling and link optimization for both point-to-point and broadcast applications. The results, in terms of annual cost per channel to the user from a commercial view point, are described.

J.A.M.

.. Warrant I

### 15 LAUNCH VEHICLES AND SPACE **VEHICLES**

Includes boosters; manned orbital laboratories; reusable vehicles; and space stations.

N79-20171°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACE PROPULSION TECHNOLOGY OVERVIEW

J. J. Pelouch, Jr. 1979 10 p refs To be presented at Conf. on Advanced Technol. for Future Space Systems, Hampton, Va., 8-11 May 1979; sponsored by AIAA (NASA-TM-79104; E-9928) Avail: NTIS HC A02/MF A01

CSCL 21H

Chemical and electric propulsion technologies for operations beyond the shuttle's orbit with focus on future mission needs and economic effectiveness is discussed. The adequacy of the existing propulsion state-of-the-art, barriers to its utilization, benefit of technology advances, and the prognosis for advancement are the themes of the discussion. Low-thrust propulsion for large space systems is cited as a new technology with particularly high benefit. It is concluded that the shuttle's presence for at least two decades is a legitimate basis for new propulsion technology, but that this technology must be predicted on an awareness of mission requirements, economic factors, influences of other technologies, and real constraints on its utilization.

### 16 SPACE TRANSPORTATION

Includes passenger and cargo space transportation e.g., shu...e operations; and rescue techniques.

For related information see also 03 Air Transportation and Safety and 85 Urban Technology and Transportation.

N79-25129\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOW-THRUST CHEMICAL ORBIT TRANSFER PROPUL-

J. J. Pelouch, Jr. 1979 22 p refs Presented at the 15th Joint Propulsion Conf., Las Vegas, Nev., 18-20 Jun. 1979; sponsored by AIAA, Soc. of Automotive Engr., and ASME (NASA-TM-79190, E-059) Avail: NTIS HC A02/MF A01 CSCL 228

The need for large structures in high orbit is reported in terms of the many mission opportunities which require such structures. Mission and transportation options for large structures are presented, and it is shown that low-thrust propulsion is an enabling requirement for some missions and greatly enhancing to many others. Electric and low-thrust chemical propulsion are compared, and the need for an requirements of low-thrust chemical propulsion are discussed in terms of the interactions that are perceived to exist between the propulsion system and the large structure.

N79-27235°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HIGH VOLTAGE SURFACE-CHARGED ENVIRONMENT TEST RESULTS FROM SPACE FLIGHT AND GROUND SIMULATION EXPERIMENTS

Norman T. Grier 1979 13 p refs Presented at the High Voltage Workshop, Anaheim, Calif., 26-27 Feb. 1979, sponsored by the AIAA

(NASA-TM-79184; E-051) Avail: NTIS HC A02/MF A01 CSCL

Surface-charged particle interactions were investigated for a small 100 sq cm conventionally constructed solar cell panel in ground facilities and in a flight experiment. The flight data substantiated preflight ground test results showing that at high positive biases the cover glass over each solar cell enhances the coup. In government, at high negative biases, arcs create large transients in the coupling current.

N79-27236°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A THERMAL CONTROL APPROACH FOR A SOLAR ELECTRIC PROPULSION THRUST SUBSYSTEM

Joseph E. Maloy and Jon C. Oglebay Jun 1979 22 p refs (NASA-TM-79175; E-040) Avail: NTIS HC A02/MF A01 CSCL 21C

A thrust subsystem thermal co.; trol design is defined for a Solar Electric Propulsion System (SEPS) proposed for the comet Halley Flyby/comet Tempel 2 rendezvous mission. A 114 node analytic model, developed and coded on the systems improved numerical differencing analyzer program, was employed. A description of the resulting thrust subsystem thermal design is presented as well as a description of the analytic model and comparisons of the predicted temperature profiles for various SEPS thermal configurations that were generated using this model. It was concluded that (1) a BIMOD engine system thermal design can be autonomous: (2) an independent thrust subsystem thermal design is feasible; (3) the interface module electronics temperatures can be controlled by a passive radiator and supplementary heaters. (4) maintaining heat pipes above the freezing point would require an additional 322 watts of supplementary heating power for the situation where no thrusters are operating; (5) insulation is required around the power processors, and between the interface module and the avionics module, as well as in those areas which may be subjected to so it heating, and (6) insulation behind the heat pipe radiators is not necessary

# 17 SPACECRAFT COMMUNICATIONS, COMMAND AND TRACKING

includes telemetry; space communications networks; astronavigation; and radio blackout.

For related information see also 04 Aircraft Communications and Navigation and 32 Communications.

N79-20176° National Agronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GLOBAL DISASTER SATELLITE COMMUNICATIONS SYSTEM FOR DISASTER ASSESSMENT AND RELIEF COORDINATION

B. E. Leroy 1979 12 p refs Presented at the Intern. Telecommun. Exposition, Dallas, 26 Feb. - 2 Mar. 1979 (NASA-TM-79105; E-9929) Avail: NTIS HC A02/MF A01 CSCL 17B

The global communication requirements for disaster assistance and examinee operationally feasible satellite system concepts and the associated system parameters are analyzed. Some potential problems associated with the current method of providing disaster assistance and a scenario for disaster assistance relying on satellite communications are described. Historical statistics are used with the scenario to assess service requirements. Both present and planned commercially available systems are considered. The associated global disaster communication yearly service costs are estimated.

N79-21120° National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

THERMAL ANOMALIES OF THE TRANSMITTER EXPERIMENT PACKAGE ON THE COMMUNICATIONS TECHNOLOGY SATELLITE

Robert E. Alexovich and Arthur N. Curren Apr. 1979 113 p. refs.

(NASA-TP-1410, E-9735) Avail: NTIS HC A06/MF A01 CSCL 178

The causes of four temporary thermal-control-system malfunctions that gave rise to unexpected temperature excursions in the 12-gigahertz, 200-watt transmitter experiment package (TEP) on the Communications Technology Satellite were investigated. The TEP consists of a nominal 200-watt output stage tube (OST), a supporting power-processing system (PPS), and a variable-conductance heat-pipe system (VCHPS). The VCHPS. which uses three heat pipes to conduct heat from the body of the OST to a radiator fin, was designed to maintain the TEP at safe operating temperatures at all operating conditions. On four occasions during 1977, all near the spring and fall equinoxes, the OST body temperature and related temperatures displayed sudden, rapid, and unexpected rises above normal levels while the TEP was operating at essentially constant, normal conditions. The temperature excursions were terminated without TEP damage by reducing the radio frequency (RF) output power of the OST Between the anomalies and since the fourth, the thermal control system has apparently functioned as designed. The results indicate the most probable cause of the temperature anomalies is depriming of the arteries in the variable-conductance heat pipes. A mode was identified in which the TEP, as presently configured, may operate with stable temperatures and with minimum change in SES performance level

N79-23999\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

COMMUNICATIONS TECHNOLOGY SATELLITE: UNITED STATES EXPERIMENTS AND DISASTER COMMUNICATIONS APPLICATIONS

Patrick Donoughe, Henry R. Hunczak, and Guy S. Gurski. 1978. 45 p. refs. Presented at the United Regional Seminar on the Use of Satellite Technol. for Disaster Appl., Sao Paulo, Brazil. 2-13 Oct. 1978

(NASA-TM-79109: E-9935) Avail: NTIS HC A03/MF A01 CSCL 178

Ground antennas from 0.6 to 5.0 meters in diameter were used as remote earth terminals by the United States for both wideband (television) and narrowband (voice, data) communication in conjunction with the Canadian Hermes satellite's high power transmitter. Experiments summarized cover teleconferencing and duplex videoconferencing for medical, educational, and civic purposes, as well as the remote interpretation of multilingual broadcasts from the United Nations. The capabilities of the system during real and simulated disasters at airports are assessed. Particular attention is given to miniexperiments for flood control in the Mississippi River basin and in Johnstown, Pennsylvania during the 1977 flood.

A.R.H.

N79-31264\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LIFE CHARACTERISTICS ASSESSMENT OF THE COM-MUNICATIONS TECHNOLOGY SATELLITE TRANSMITTER EXPERIMENT PACKAGE

Jerry Smetana and Arthur N. Curren Jul. 1979 52 p. refs (NASA-TM-79181; E-049) Avail. NTIS HC A04/MF A01 CSCL 178

The performance characteristics of the transmitter experiment package (TEP) aboard the Communications Technology Satellite (CTS) measured during its first 2 years in orbit are presented. The TEP consists of a nominal 200 watt output stage tube (OST), a supporting power processing system (PPS), and a variable conductance heat pipe system (VCHPS). The OST, a traveling wave tube augmented with a 10 stage depressed collector has an overall saturated average efficiency of 51.5 percent and an average saturated radio frequency (rf) output power at center band frequency of 240 watts. The PPS operated with a measured efficiency of 86.5 to 88.5 percent. The VCHPS, using three pipes to conduct heat from the PPS and the OST to a 52 by 124 centimeter radiator fin, maintained the PPS baseplate temperature below 50 C for all operating conditions. The TEP performance characteristics presented include frequency response. rf output power, thermal performance, and efficiency. Communications characteristics were evaluated by using both video and audio modulated signals. On four occasions, the TEP experienced temporary thermal control system malfunctions. The anomalies were terminated safely, and the problem was investigated because of the potential for TEP damage due to the signficant temperature increases. Safe TEP operating procedures were established

A79-20877 \*\* Laboratory studies of electrical properties of insulating materials. J. E. Nanevicz, R. C. Adamo (SRI International, Menlo Park, Calif.), and N. Grier (NASA, Lewis Research Center, Cleveland, Ohio). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 1190-1201.

The characteristics of satellites are influenced by the electrical properties of the dielectric exterior. It was found in simulated space environment tests that the electrical conductivities of dielectrics are affected as the result of interactions with various components of the environment. The degree to which the conductivity was affected varied with material. In some instances the changes found to occur could be used to advantage, particularly if they could be enhanced. For example, the increased electrical conductivity of Kapton resulting from solar illumination could be used to advantage to eliminate the charge storage leading to electrical breakdown during magnetic substorms. Similarly the relative immunity of FEP Teflon to change from response to the space environment makes it a logical choice as a solar cell cover in a high-voltage solar array.

G.R.

A79-51097 \* # VHF downlink communication system for SLAR data. R. J. Schertler, T. L. Chase, R. A. Mueller, I. Kramarchuk, R. J. Jirberg, and R. T. Gedney (NASA, Lewis Research Center, Cleveland, Ohio). University of Michigan, International Symposium on Remote Sensing of Environment, 13th, Ann Arbor, Mich., Apr. 23-27, 1979, Paper. 8 p.

This paper describes a real-time VHF downlink communication system for transmitting side-looking airborne-radar (SLAR) data directly from an aircraft to a portable ground/shipboard receiving station, Use of this receiving station aboard the U.S. Coast Guard icebreaker Mackinaw for generating real-time photographic quality radar images will be discussed. The system was developed and demonstrated in conjunction with the U.S. Coast Guard and NOAA National Weather Service as part of the Project Icewarn all-weather ice information system for the Great Lakes Winter Navigation Program. (Author)

A79-45374 \* # Bilinear tangent yaw guidance. R. G. Brusch (General Dynamics Corp., Convair Div., San Diego, Calif.). In: Guidance and Control Conference, Boulder, Colo., August 6-8, 1979, Collection of Technical Papers. (A79-45351 19-12) New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 250-264, 23 refs. Contract No. NAS3-19154. (AIAA 79-1730)

This paper presents a parametric yaw steering law which has been used to provide closed-loop yaw guidance for the launch of the HEAO (High Energy Astronomy Observatory) satellite mission using the Atlas/Centaur launch vehicle. This bilinear tangent steering law provides near optimal yaw steering for maneuvers requiring insertion into orbits with a specified inclination and node. Bilinear tangent steering is shown to be optimal in both the pitch and yaw planes when a uniform gravitational field is assumed. The conditions under which the general bilinear tangent laws degenerate into linear tangent and constant attitude laws are presented. The flight computer implementation of these laws in a rotating coordinate syste a using real-time integration of the equations of motion is detailed. Explicit solution of the parametric guidance equations requires the inflight solution of (2x2) two-point boundary value problems in the pitch and yaw pianes. Excellent results are obtained even for very large (greater than 50 deg) out-of-plane steering angles. (Author)

## 18 SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Includes spacecraft thermal and environmental control; and attitude control

For life support systems see 54 Man/System Technology and Life Support. For related information see also 05 Aircraft Design, Testing and Performance and 39 Structural Mechanics.

N79-11109°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## INSULATOR EDGE VOLTAGE GRADIENT EFFECTS IN SPACECRAFT CHARGING PHENOMENA

N John Stevens, Carolyn K. Purvis, and John V Staskus 1978 16 p. refs. Presented at the Ann. Conf. on Nucl. and Space Radiation Effects, Albuquerque, N. Mex., 18-21 Jul. 1978, sponsored by IEEE

(NASA-TM 78988, E-9769) Avail NTIS HC A02/MF A01 CSCL 22B

Insulating surfaces on geosynchronous satellites were charged by geomagnetic substorms to a point where discharges occur. The electromagnetic pulses from these discharges couple into satellite electronic systems disrupting operations are examined. Laboratory tests conducted on insulator charging have indicated that discharges appear to be initiated at insulator edges where voltage gradients can exist. An experimental investigation was conducted to measure edge voltage gradients on silvered Teflon samples as they are charged by monoenergetic electron beams It was found that the surface voltage at insulator edges can be approximated by an exponential expression based on an electron current density balance.

N79-15149°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

JUPITER PROBE CHARGING STUDY

Carolyn K Purvis Jan 1979 38 p refs

(NASA-TP-1263; E-9167) Avail: NTIS HC A03/MF A01 CSCL 22B

A model to predict spacecraft charging effects in the Jovian magnetosphere was developed for the preliminary design of a Jupiter probe. Charging calculations made with this model are presented and discussed. Differential potentials between interior and exterior surfaces and between sunlit and dark exterior surfaces are predicted to be in the kilovolt range.

Author

N79-15150\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### SPACE ENVIRONMENTAL INTERACTIONS WITH SPACE-CRAFT SURFACES

John N Stevens 1979 23 p . efs Presented at 17th Aerospace Sci. Meeting, New Orleans, La., 15-17 Jan 1979 Sponsored by AIAA

(NASA-TM-79016, E-9805) Avail NTIS HC A02/MF A01 CSCL 22B

Environmental interactions are defined as the response of spacecraft surfaces to the charged-particle environment. These interactions are divided into two broad categories: spacecraft passive, in which the environment acts on the surfaces and spacecraft active, in which the spacecraft or a system on the spacecraft causes the interaction. The principal spacecraft passive interaction of concern is the spacecraft charging phenomenon. The spacecraft active category introduces the concept of interactions with the thermal plasma environment and Earth's magnetic fields, which are important at all altitudes and must be considered the designs of proposed large space structures and space power systems. The status of the spacecraft charging investigations is reviewed along with the spacecraft cative.

N79-22097\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### DESIGN PROBLEMS OF SMALL TURBOMACHINERY

H. E. Rohlik In Von Karman Inst. for Fluid Dyn. Closed Cycle Gas Turbines 1970 11 p refs (For primary document see N79-22093 13-07)

Avail: NTIS HC A15/MF A01 CSCL 21E

Advanced design and testing techniques developed at NASA Lewis to achieve high efficiency in small turbomachines are described. Small radial and axial turbines and compressors were built for space power systems and associated studies at the Lewis Research Center. A six stage axial compressor of 3.5 inches diameter and axial turbines of 5 and 8.5 inches diameter were included. Radial turbines and compressors ranged from 3.5 to 6 inches. Topics discussed include maximum efficiency as a function of speed, the effect of compressibility on passage size, the use of quasi-orthogonals to calculate cross-channel velocity gradients, a design point velocity diagram study for axial turbines, and estimating off-design performance. Special turbine instruments and calibration procedures were developed to test compressors and turbines, to determine Reynolds and size number effects clearance, specific speed effects, and compressor performance. Laboratory tests conducted to study system operation and shaft and bearing motions are also reviewed.

N79-22188\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### LARGE SPACE SYSTEM: CHARGED PARTICLE ENVIRON-MENT INTERACTION TECHNOLOGY

N. John Stevens, James C. Roche, and Normant T. Grier 1979 23 p refs Presented at the Conf on Advancer Technol for Future Space Systems, Hampton, Va., 8-11 May 1979; sponsored by AIAA

(NASA-TM-79156; E-012) Avail: NTIS HCA02/MF A01 CSCL 22B

Large, high voltage space power systems are proposed for future space missions. These systems must operate in the charged-particle environment of space and interactions between this environment and the high voltage surfaces are possible. Ground simulation testing indicated that dielectric surfaces that usually surround biased conductors can influence these interactions. For positive voltages greater than 100 volts, it has been found that the dielectrics contribute to the current collection area. For negative voltages greater than-500 volts, the data indicates that the dielectrics contribute to discharges. A large, high-voltage power system operating in geosynchronous orbit was analyzed. Results of this analysis indicate that very strong electric fields exist in these power systems.

N79-24000\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## NASCAP MODELLING OF HIGH-VOLTAGE POWER SYSTEM INTERACTIONS WITH SPACE CHARGED-PARTICLE ENVIRONMENTS

N. John Stevens, James C. Roche, and Myron J. Mandell (Systems, Science and Software, La Jolla, Calif.) 1979–20 p. refs. Presented at the High Voltage Workshop, Anaheim, Calif., 26-27 Feb. 1979; sponsored by IEEE

(NASA-TM-79146, E-001) Avail NTIS HC A02/MF A01 CSCL 22B

A simple space power system operating in geosynchronous orbit was analyzed. This system consisted of two solar array wings and a central body. Each solar array wing was considered to be divided into three regions operating at 2000 volts. The center body was considered to be an electrical ground with the array voltages both positive and negative relative to ground. The system was analyzed for both a normal environment and a moderate geomagnetic substorm environment. Initial results indicate a high probability of arcing at the interconnects on the negative operating voltage wing. The dielectric strength of the substrate may be exceeded giving rise to breakdown in the bulk of the material. The geomagnetic substorm did not seem to increase the electrical gradients at the interconnects on the negative operating voltage wing but did increase the gradients on the positive operating voltage wing which could result in increased coupling current losses.

N79-24001\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACECRAFT CHARGING TECHNOLOGY, 1978

1979 908 p refs Conf. held at Colorado Springs, Colo., 31 Oct. - 2 Nov. 1978; sponsored by NASA and AFGL (NASA-CP-2071; AFGL-TR-79-0082) Avail: NTIS HC A99/MF A01 CSCL 22B

The interaction of the aerospace environment with spacecraft surfaces and onboard, high voltage spacecraft systems operating over a wide range of altitudes from low Earth orbit to geosynchronous orbit is considered. Emphasis is placed on control of spacecraft electric potential. Electron and ion beams, plasma neutralizers material selection, and magnetic shielding are among the topics discussed. For individual titles, see N79-24002 through N79-24057.

N79-24006\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SUMMARY OF THE TWO YEAR NASA PROGRAM FOR ACTIVE CONTROL OF ATS-5/6 ENVIRONMENTAL CHARGING

Robert O. Bartlett and Carolyn K. Purvis. *In its* Spacecraft Charging Technol., 1978—1979—9 44-58 refs. Prepared in cooperation with NASA. Goddard Space Flight Center (For primary document see N79-24001 15-18).

Avail: NTIS HC A99/MF A01 CSCL 22B

Experiments conducted on the ATS 5 and ATS 6 which have demonstrated the feesibility of modifying or clamping the environmentally induced potential of these spacecraft are described. The results of these experiments indicate that a thermionic electron source is capable of replacing photo-emitted electrons during eclipse. However, the utility of this type of device is limited if its emission is suppressed by local electric fields. On the other hand, it is shown that a plasma source will not only serve as a substitute for photo-emitted electrons but will also suppress differential charging of isolated elements of the spacecraft which would tend to suppress electron emission. This later device is therefore capable of clamping the potential of a spacecraft without special considerations of its coupling to the ambient plasma.

J.M.S.

N79-24011\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## THE CAPABILITIES OF THE NASA CHARGING ANALYZER PROGRAM

Katz, J. J. Cassidy, M. J. Mandell, G. W. Schnuelle, P. G. Steen, and J. C. Roche. In its Spacecraft Charging Technol., 1978. 1979. p. 101-122. refs. Prepared in cooperation with Systems, Science and Software, La Jolla, Calif. (For primary document see N79-24001. 15-18).
 (Contract NAS3-21050).

Avail. NTIS HC A99/MF A01 CSCL 22B

Desirable features in a spacecraft modeling code are enumerated. The NASCAP is discussed in terms of its approach to the problem. Samples of problem setup and output are provided which demonstrate the ease with which the program can be used. A simple but interesting case of spacecraft charging is examined, and other applications are discussed.

Author

N79-24013\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON OF NASCAP PREDICTIONS WITH EXPERIMENTAL DATA

James C. Roche and Carolyn K. Purvis. *In its* Spacecraft Charging Technol., 1978—1979—p. 144-157—refs (For primary document see N79-24001—15-18)

Avail NTIS HC A99/MF A01 CSCL 22B

The NASA charging analyzer program (NASCAP) is a three dimensional, finite element computer code capable of simulating the electrostatic charging of an arbitrary body either in a ground test tank or in the space environment. The code incorporated surface property parameters needed to simulate insulating and conducting materials. These parameters are being updated as equired to bring the NASCAP predictions into correspondence.

with data from ground tests. NASCAP predictions are also being compared with data from the ATS 5 spacecraft. The significance of these results is discussed.

J.A.M.

N79-24021°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INTERACTIONS BETWEEN SPACECRAFT AND THE CHARGED-PARTICLE ENVIRONMENT

N. John Stevens In its Spacecraft Charging Technol., 1973 1979 p 268-294 refs (For primary document see N79-24001 15-18)

Avail: NTIS HC A99/MF A01 CSCL 22B

Spacecraft-environment interactions are defined as the responses of a spacecraft surface to a charged-particle environment. This response can influence spacecraft system performance. Interactions can be divided into two broad categories: spacecraft passive, in which the environment acts on the spacecraft; and spacecraft active, in which the spacecraft causes the interaction. Passive interactions include the spacecraft-charging phenomenon. Active interactions include the relatively new interactions arising from the use of very large spacecraft and space power systems in future missions. To illustrate active interactions, a large power system operating at elevated voltages is considered. Possible interactions are described, available experimental data are reviewed, and the effect on power system performance is estimated.

N79-24022\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PLASMA INTERACTION EXPERIMENT (PIX) FLIGHT RESULTS

Norman T. Grier and N. John Stevens *In its* Spacecraft Charging Technol., 1978 1979 p 295-314 refs (For primary document see N79-24001 15-18)

Avail: NTIS HC A99/MF A01 CSCL 22B

An auxiliary payload package called PIX (plasma interaction experiment) was launched on March 5, 1978, on the LANDSAT 3 launch vehicle to study interactions between the space charged-particle environment and surfaces at high applied positive and negative voltages. Three experimental surfaces were used in this package: a plain disk to act as a control, a disk on a Kapton sheet to determine the effect of surrounding insulation on current collection, and a small solar-array segment to evaluate the effect of distributing biased surfaces among an array of insulators. Only half of the results from the 4 hours of PIX operations were recovered. The results did verify effects found in ground simulation testing. The results of this experiment are discussed in detail.

N79-24026\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF PARASITIC PLASMA CURPENTS ON SOLAR-ARRAY POWER OUTPUT

Stanley Domitz and Joseph C. Kolecki. In his Spacec aft Charging Technol., 1978—1979—p. 358-375—refs. (For primary document see N79-24001-15-18).

Avail NTIS HC A99/MF A01 CSCL 22B

Solar-array voltage-current curves are calculated by assuming the existence of parasitic loads that consist of local currents of charged particles collected by the array. Three cases of interest are calculated to demonstrate how the distribution and magnitude of parasitic currents affect output. Solar array performance degradation became significant when the total parasitic current plus the load current exceeded the short-circuit current. Approximate graphical methods were useful for many applications. Power loss, which was calculated by summing the product of parasitic current and the local potential, underestimated the loss in maximum power.

N79-24030\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STATUS OF MATERIALS CHARACTERIZATION STUDIES Carolyn K. Purvis Ir. its Spacecraft Charging Technol., 1978 1979 p 437-456 refs (For primary document see N79-24001 15-18)

Avail: NTIS HC A99/MF A01 CSCL 22B

In the context of the spacecraft charging technology investigation, studies were made to characterize the response of typical spacecraft surface materials to the charging environment. The objective is to obtain an understanding of the charging and discharging behavior of such materials for the reliable prediction of spacecraft response to charging environments and as a guide for the design of future spacecraft. Materials were characterized in terms of such basic properties as resistivity and secondary emission and in terms of charging and discharging behavior in simulated charging environments.

N79-24031\*# National Aeronautics and Sp≥ce Administration. Lewis Research Center, Cleveland, Ohio.

TEST RESULTS FOR ELECTRON BEAM CHARGING OF FLEXIBLE INSULATORS AND COMPOSITES

John V. Staskus and Frank D. Berkopec *In its* Spacecraft Charging Technol., 1978 1979 p 457-484 refs (For primary document see N79-24001 15-18)

Avail: NTIS HC A99/MF A01 CSCL 22B

Flexible solar-array substrates, graphite-fiber/epoxy - aluminum honeycomb panels, and thin dielectric films were exposed to monoenergetic electron beams ranging in energy from 2 to 20 k€V in the Lewis Research Center's geomagnetic-substormenvironment simulation facility to determine surface potentials. dc currents, and surface discharges. The four solar-array substrate samples consisted of Kapton sheet reinforced with fabrics of woven glass or carbon fibers. They represented different construction techniques that might be used to reduce the charge accumulation on the array back surface. Five honeycomb-panel samples were tested, two of which were representative of Voyager antenna materials and had either conductive or nonconductive painted surfaces. A third sample was of Navstar solar-array substrate material. The other two samples were of materials proposed for use on Intelsat V. All the honeycomb-panel samples had graphite-fiber/epoxy composite face sheets. The thin dielectric films were 2.54-micrometer-thick Mylar and 7.62-micrometer-thick Kapton ARH

N79-24032\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

## AREA SCALING INVESTIGATIONS OF CHARGING PHENOMENA

Paul R. Aron and John V. Staskus. *In its*. Spacecraft Charging Technol. 1978. 1979. p. 485-506. refs. (For primary document see N79-24001. 15-18).

Avail NTIS HC A99/MF A01 CSCL 22B

The charging and discharging behavior of square, planar samples of silvered, fluorinateo ethylene-propylene (FEP) Teflon thermal control tape was measured. The equilibrium voltage profiles scaled with the width of the sample. A wide range of discharge pulse characteristics was observed, and the area dependences of the peak current, charge, and pulse widths are described. The observed scaling of the peak currents with area was weaker than that previously reported. The discharge parameters were observed to depend strongly on the grounding impedance and the beam voltage Preliminary results suggest that measuring only the return-current-pulse characteristics is not adequate to describe the spacecraft discharging behavior of this material. The seams between strips of tape appear to play a fundamental role in determining the discharging behavior. An approximate propagation velocity for the charge cleanoff was extracted from the data. The samples 232, 1265, and 5058 square centimeters in area - were exposed at ambient temperature to a 1- to 2-nA/sq cm electron beam at energies of 10, 15, and 20 kilovolts in a 19-meter long by 46-meter diameter simulation facility at the Lewis Research Center Author

N79-24033\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CHARGING RATES OF METAL-DIELECTRIC STRUCTURES
Carolyn K. Purvis, John V. Staskus, James C. Roche, and Frank
D. Berkopec In its Spacecraft Charging Technol., 1978 1979
p. 507-523 refs (For primary document see N79-24001 15-18)
Avail NTIS HC A99/MF A01 CSCL 228

Metal plates partially covered by 0.01-centimeter-thick fluorinated ethylene-propylene (FEP) Teffon were charged in the Lewis Research Center's geomagnetic substorm simulation facility using 5-, 8-, 10-, and 12-kilovolt electron beams. Surface voltage as a function of time was measured for various initial conditions (Teflon discharged or precharged) with the metal plate grounded or floating. Results indicate that both the charging rates and the levels to which the samples become charged are influenced by the geometry and initial charge state of the insulating surfaces. The experiments are described and the results are presented and discussed. NASA charging analyzer program (NASCAP) models of the experiments have been generated, and the predictions obtained are described. Implications of the study results for spacecraft are discussed.

N79-31265\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASCAP MODELLING OF ENVIRONMENTAL-CHARGING-INDUCED DISCHARGES IN SATELLITES

N. John Stevens and James C. Roche 1979 25 p refs Presented at Ann. Conf. on Nucl. and Space Radiation Effects, Santa Cruz. Calif. 17-20 Jul. 1979; sponsored by IEEE

(NASA-TM-79247; E-155) Avail: NTIS HC A02/MF A01 CSCL 22B

The charging and discharging characteristics of a typical geosynchronous satellite experiencing time-varying geomagnetic substorms, in sunlight, were studied utilizing the NASA Charging Analyzer Program (NASCAP). An electric field criteria of 150,000 volts/cm to initiate discharges and transfer of 67 percent of the stored charge was used based on ground test results. The substorm characteristics were arbitrarily chosen to evaluate effects of electron temperature and particle density (which is equivalent to current density). It was found that while there is a minimum electron temperature for discharges to occur, the rate of discharges is dependent on particle density and duration times of the encounter. Hence, it is important to define the temporal variations in the substorm environments.

A79-30139 \* ... Insulator edge voltage gradient effects in spacecraft charging phenomena. N. J. Stevens, C. K. Purvis, and J. V. Staskus (NASA, Lewis Research Center, Cleveland, Ohio). (IEEE, DNA, NASA, and DOE Annual Conference on Nuclear and Space Radiation Effects, 15th, Albuquerque, N. Mex., July 18-21, 15-78.) IEEE Transactions on Nuclear Science, vol. NS-25, Dec. 1978, p. 1304-1312, 22 refs.

Insulating surfaces on geosynchronous satellites have been charged by geomagnetic substorms to a point where discharges occur. The electromagnetic pulses from these discharges couple into satellite electronic systems disrupting operations. Laboratory tests conducted on insulator charging have indicated that discharges appear to be initiated at insulator edges where voltage gradients can exist. An experimental investigation has been conducted to measure edge voltage gradients on silvered Teflon samples as they are charged by monoenergetic electron beams. It has been found that the surface voltage at insulator edges can be approximated by an exponential expression based on an electron current density balance. Using this expression at known breakdown conditions results in a discharge voltage gradient down the insulator edge to ground of about 150,000 V/cm. (Author)

A79-30140 \* The decrease in effective photocurrents due to saddle points in electrostatic potentials near differentially charged spacecraft. M. J. Mandell, I. Katz, G. W. Schnuelle, P. G. Steen (Systems, Science and Software, La Jolla, Calif.), and J. C. Roche (NASA, Lewis Research Center, Cleveland, Ohio). (IEEE, DNA, NASA, and DOE, Annual Conference on Nuclear and Space Radiation Effects, 15th, Albuquerque, N. Mex., July 18-21, 1978.) IEEE Transactions on Nuclear Science, vol. NS-25, Dec. 1978, p. 1313-1317. 9 refs. Contract No. NAS3-21050.

The reported investigation had the objective to illustrate the presence of important multidimensional effects in spacecraft charging. Two-dimensional codes have been under development by Parker (1976). A description is presented of a calculation which was performed using the three-dimensional NASA Charging Analyzer Program (NASCAP). NASCAP was run to calculate the electrostatic potentials on the surface of, and in the space surrounding, a sunlit Teflon-coated sphere. Currents to the sunlit surfaces were determined on the basis of an approximate photosheath model for strong differential charging.

G.R.

A79-23511 \* # Space environmental interactions with space-craft surfaces. N. J. Stevens (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0386, 25 p. 47 refs.

The employment of large structures in space, which would be necessary in connection with a number of space missions and space activities currently being contemplated, might involve special problems as a result of the interactions of the structures with the charged particle environment. Such interactions would be particularly significant in the case of high operational voltages. A review is presented of possible interactions between spacecraft surfaces and charged particle environments. The categories of spacecraft-environmental interactions are examined and a description of spacecraft charging interactions is presented. The status of charging investigation is considered, taking into account the environment, aspects of analytical modeling, materials characterization, materials development, space flight experiments, and design guidelines. High voltage surface plasma interactions are also investigated.

G.B.

#### N79-24007\*# California Univ., San Diego OPERATIONS OF THE ATS-6 ION ENGINE

R C Olsen and E C Whipple In NASA Lewis Res Center Spacecraft Charging Technol. 1978—1979—p.59-68 refs (For primary document see N79-24001-15-18) (Grant NsG-3150)

Avail NTIS HC A99/MF A01 CSCL 22B

The ion engine experiments on ATS 6 were operated in daylight and eclipse. The effect on particle fluxes to the spacecraft was monitored with the UCSD Auroral Particles Experiment. These data also provide information on the potential of the spacecraft with respect to the ambient plasma and on the local electric fields caused by the charge distribution on the satellite. Daylight operations of the plasma bridge neutralizer and the cesium thruster in fall. 1974 served to hold the spacecraft between -3 and -8 volts with respect to the ambient plasma. Neutralizer operation reduced differential charging effects, while operation of the thruster usually reduced the effects below the detectors sensitivity. Eclipse operations of the neutralizer reduced kilovolt negative potentials to a few volts. Operation of the thruster prevented possible charging of the satellite during substorms, making it possible to study low energy particle spectra which are at times obscured by charging during substorms JMS

#### N79-24008° # California Univ. San Diego CHARACTERISTICS OF DIFFERENTIAL CHARGING OF ATS-6

Bruce Johnson and Elden C. Whipple In NASA. Lewis Res. Center. Spacecraft Charging Technol. 1978. 1979. p. 69-79 refs. (For primary document see N79-24001.15.18). (Grant. NsG-3150).

Avail NTIS HC . 99/MF A01 CSCL 22B

Thirteen day. I data collected by the Auroral Particle Experiment onh ard the ATS 6 were analyzed emphasizing peculiarities in the lectron data attributed to differential charging. On one of these cays the satellite was eclipsed by the earth at local midnight. Spectrograms were used to examine the data. It is concluded that differential charging is responsible for returning photoelectrons to the spacecraft up to a couple hundred eV, depending on the spacecraft charge. It is believed that the Minnesota experiment on ATS 6 is largely responsible for producing a potential barrier that returns particles and produces intense spon spots in the count rates.

J.M.S.

## N79-24038° # Pennsylvania State Univ., University Park. POTENTIAL MAPPING WITH CHARGED-PARTICLE BEAMS

James W. Robinson and David G. Tillery /n NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 1979 p 606-620 refs (For primary document see N79-24001 15-18) (Grant NsG-3166)

Avail NTIS HC A99/MF A01 CSCL 22B

Experimental methods of mapping the equipotential surfaces near some structure of interest rely on the detection of charged particles which have traversed the regions of interest and are detected remotely. One method is the measurement of ion energies for ions created at a point of interest and expelled from the region by the fields. The ion energy at the detector in eV corresponds to the potential where the ion was created. An ionizing beam forms the ions from background neutrals. The other method is to inject charged particles into the region of interest and to locate their exit points. A set of several trajectories becomes a data base for a systematic mapping technique. An iterative solution of a boundary value problem establishes concepts and limitations pertaining to the mapping problem.

#### N79-24046\*# Pennsylvania State Univ., University Pa.k STABLE DIELECTRIC CHARGE DISTRIBUTIONS FROM FIELD ENHANCEMENT C7 SECONDARY MISSION

James W Robinson In NASA. Lewis Res. Center Spacecraft Charging Technol. 1978 1979 p 734-746 refs (For primary document see N79-24001 15-18) (Grant NsG-3097)

Avail NTIS HC A99/MF A01 CSCL 22B

The emission of secondary electrons from dielectrics subject to numerous effects of electric field which are experimentally difficult to control is discussed. Measurements are reported using pulse techniques such that local fields do not build to significant levels, but measurements with fields present are also of interest. A specific series of measurements under controlled conditions are described and their implications in terms of fields, magnitude and angle, near the dielectric surface were examined. The measurements were made for a charged fluorinated-ethylene-propylene surface near a grounded aluminum half-round resting on the surface. The geometry produced a stable surface-charge gradient being controlled by a strongly enhanced secondary emission for which a model is constructed. Observations of surface flashovers under various conditions confirm the predictions of some scaling exercises.

## N79-24012\*# Systems Science and Software, La Jolla, Calif CHARGING ANALYSIS OF THE SCATHA SATELLITE

G W Schnuelle, D E Parks, I. Kaz, M J Mandell, P C Steen, J J Cassidy and A G Rubin (AFGL) /n NASA. Lewis hes Center Spacecraft Charging Technol 1978—1979—p 123-143 refs (For \_\_imary document see N79-24001 15-18) (Contract NAS3 21050)

Avail NTIS HC A99/MF A01 CSCL 22B

A detailed model of the geometrical, material and electrical properties of the SCATHA satellite for use with the NASA charging analyzer program is described. Charging calculations in an intense magnetospheric substorm environment demonstrated that (1) long booms can significantly perturb the potentials near the space: aft. and (2) discharging by sunlight or by active control can cause serious time-dependent differential charging problems:

J.A.M.

N79-24049\*# Hiram Coll., Ohio.

GEOSYNCHRONOUS SATELLITE OPERATING ANOMALIES CAUSED BY INTERACTION WITH THE LOCAL SPACE-CRAFT ENVIRONMENT

Michael A. Grajek and Donald A. McPherson (Science Applications, Inc.) In NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 1979 p 769-782 refs (For primary document see N79-24001 15-18)

(Contracts NAS3-21048; F04071-77-C-0166) Avail: NTIS HC A39/MF A01 CSCL 22B

The dependence of a spacecraft anomaly or event upon geophysical parameters established on the basis of statistical analysis is presented. Examples are provided for establishing relationships between events and parameters such as geomagnetic activity, local time, and events on other spacecraft. Examples illustrated the potential dangers of not using quantitative statistical techniques it was recommended that the data collection planning and statistical analysis planning be done together. Results demonstrate a high correlation between the events and the goephysical parameter being investigated. SES

N79-24061\* Science Applications, Inc., La Jolla, Calif. SPACECRAFT CHARGING MODELING DEVELOPMENT AND VALIDATION STUDY

E. E. ODonnell In NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 1979 p 797-816 refs (For primary document see N79-24001 15-18)

(Contracts NAS3-21048: F04701-77-C-0166) Avail IIIS HC A99/MF A01 CSCL 22B

The effects of spacecraft charging are presented. Analytical models of the magnetospheric environment are used to show the charging interaction between the spacecraft and the plasma sheath, the discharge phenomena, and electromagnetic coupling from the discharge to spacecraft components. Ground tests to validate the models are described.

M79-27234°# General Dynamics/Convair, San Diego, Calif. ATLAS 5013 TANK CORROSION TEST Final Report W. M. Sutherland, L. D. Girton, and D. G. Treadway 1978 133 p re/s (Contract NAS3-20644) NTIS Avail

CASD-LVP-78-078) (NASA-CR-158760;

HC A07/MF A01 CSCL 22B

The type and cause of corrosion in spot welded joints were determined by X-ray and chemical analysis Fatigue and static tests showed the degree of degradation of mechanical properties. The corrosion inhibiting affectiveness of WD-40 compound and required renewal period by exposing typical joint specimens were examined

## 19 SPACECRAFT INSTRUMENTATION

For related information see also 06 Aircraft Instrumentation and 35 Instrumentation and Photography.

A79-39806 \* # NASCAP modelling of high-voltage power system interactions with space charged-particle environments. N. J. Stevens, J. C. Roche (NASA, Lewis Research Center, Cleveland, Ohio), and M. J. Mandel! (System, Science and Software, La Joila, Calif.). Institute of Electrical and Electronics Engineers, High Voltage Workshop, Anaheim, Calif., Feb. 26, 27, 1979, Paper. 18 p. 22 refs.

The NASA Charging Analyzer Program (NASCAP), an engineering tool capable of analyzing the impact of the charged particle environment on spacecraft surfaces and systems, is described. NASCAP is a quasi-static computational program which analyzes the charging of a 3-dimensional complex body as a function of time and system-generated voltages for given space environmental conditions. The material properties of the surfaces are taken into account, the surface potentials, low energy sheath, potential distribution in space and particle trajectories are calculated. An application of NASCAP to a simple space solar power station consisting of two 6 m by 18 m solar array wings surrounding a central body is presented. Each solar array wing is considered to be divided into three regions operating at 2000 volts. Results of NASCAP analysis of the system for a normal environment and a moderate geomagnetic substorm environment are discussed.

C.K.D.

## 20 SPACECRAFT PROPULSION AND POWER

Includes main propulsion systems and components e.g. rocket engines, and spacecraft auxiliary power sources.

For related informatio i see also 07 Aircraft Propulsion, 28 Propellants and Fu: Is, and 44 Energy Production and Conversion.

N79-10122\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

FUTURE ORBITAL POWER SYSTEMS TECHNOLOGY REQUIREMENTS

Sep 1978 195 p refs Symp, held at Cleveland, 31 May - 1 Jun. 1978

(NASA-CF-2058; E-9713) Avail: NTIS HC A09/MF A01 CSCL

NASA is actively involvad in program planning for missions requiring several orders of magnitude, more energy than in the past. Therefore, a two-day symposium was held to review the technology requirements for future orbital power systems. The purpose of the meeting was to give leaders from government and industry a broad view of current government supported technology efforts and future program plans in space power. It provided a forum for discussion, through workshops, to comment on current and planned programs and to identify opportunities for technology investment. Several papers are presented to review the technology status and the planned programs. For individual titles, see N79-10123 through N79-10143.

## A BRIEF SURVEY OF THE SOLAR CELL STATE-OF-THE-ART

Daniel T Bernatowicz *In its*: ure Orbital Power Systems Technol Requirements Sep. 1978 p. 133-146 refs (For primary document see N79-10122 01-20)

Avail NTIS HC A09/MF A0: CSCL 10A

Modern high performance cells made for space are discussed. The major recent developments that are expected to influence what solar cells will be available in five years or so are described.

N79-10132\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

TECHNOLOGY STATUS: BATTERIES AND FUEL CELLS

J. Stuart Fordyce In its Future Orbital Power Systems Technol.

Requirements Sep 1978 p 157-166 refs (For primary document see N79-10122 01-20)

Avail NTIS HC A09/MF A01 CSCL 10A

The current status of research and development programs on batteries and fuel cells and the technology goals being pursued are discussed. Emphasis is placed upon those technologies relevant to earth orbital electric energy storage applications.

G.Y.

N79-10139\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## AN ECONOMICAL APPROACH TO SPACE POWER SYSTEMS

Fred Teren *In its* Future Orbital Power Systems Technol Requirements Sep 1978 p 265-270 (For primary document see N79-10122 01-20)

Avail NTIS HC A09/MF A01 CSCL 10A

Projected energy demand for all NASA, DoD and civil missions for the time span 1981 to 1995 are illustrated. Typical energy cost range from about \$300 to \$2000 per kW-hr, with an average of about \$800 per kW-hr for long-duration missions. At these levels, the cost of the required energy would be several billion dollars per year by about 1985 and might constrain the number and types of NASA programs to be carried out. NASA is extensively pursuing approaches for reducing nonrecurring costs.

Two programs are presented for the development of an economical approach to space power systems. They are: (1) Economical Orbital Power (ECOP) with the objective to demonstrate the applicability of a commercial approach to the development of a low cost photovoltaic space power system, and (2) Space Power Experiment (SPEX) which has the objective to demonstrate the application of industrial hardware for space power systems. G.Y.

N79-20179° National Aeronautics and Space Administration. Lawis Research Center, Cleveland, Ohio.

### CLOSED LOOP SOLAR ARRAY-ION THRUSTER SYSTEM

WITH POWER CCNTROL CIRCUITRY Patent
Robert P. Gruber, inventor (to NASA) Issued 6 Mar. 1979
8 p. Filed 29 Mar. 1978 Supersedes N78-22149 (16 - 13, p. 1673)

(NASA-Case-LEW-12780-1; US-Patent-4,143,314; US-Patent-Appl-SN-891370; US-Patent-Class-323-15;

US-Patent-Appl-SN-891370; US-Patent-Class-323-15; US-Patent-Class-323-20) Avail: US Patent and Trademark Office CSCL 20C

A power control circuit connected between a solar a-ray and an ion thruster receives voltage and current signals from the solar array. The control circuit multiplies the voltage and current signals together to produce a power signal which is differentiated with respect to time. The differentiator output is detected by a zero crossing detector and, after suitable shaping.

detected by a zero crossing detector and, after suitable shaping, the detector output is phase compared with a clock in a phase demodulator. An integrator receives no output from the phase demodulator when the operating point is at the maximum power but is driven toward the maximum power point for non-optimum operation. A rump generator provides minor variations in the beam current reference signal produced by the integrator in order

to obtain the first derivative of power.

Official Gazette of the U.S. Patent and Trademark Office

N79-20180\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

## AN OXIDE DISPERSION STRENGTHENED ALLOY FOR GAS TURBINE BLADES

T. K. Glasgow 1979 13 p refs Presented at the 20th Structures, Structural Dyn and Mater. Conf., St. Louis, 4-6 Apr. 1979; sponsored by AIME and the Am. Soc. of Civil Engr. (NASA-TM-79088; E-9912) Avail NTIS HC A02/MF A01 CSCL 21H

The strength of the newly developed alloy MA-6000E is derived from a nickel alloy base, an elongated grain structure, naturally occurring precipitates of gamma prime, and an artificial distribution of extremely fine, stable oxide particles. Its composition is Ni-15Cr-2Mo-2Ta-4W-4-5Al-2-5Ti-0.15Zr 0.05C-0.018-1. 1Y203. It exhibits the strength of a conventional nickel-base alloy at 1400 F but is quite superior at 2000 F. Its shear strength is relatively low, necessitating consideration of special joining procedures. Its high cycle, low cycle, and thermal fatigue properties are excellent. The relationship between alloy microstructure and properties is discussed.

N79-22190\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## PRIMARY ELECTRIC PROPULSION FOR FUTURE SPACE MISSIONS

David C. Byers, Fred F. Terdan, and Ira T. Myers. 1979. 45 p. refs. Presented at the Conf. on Adv. Technol. for Future Space Systems, Langley, Va. 8-11. May 1979, sponsored in part by AIAA.

(NASA-TM-79141, E-9994) Avail NTIS HC A03/MF A01 CSCL 20C

A general methodology is presented which allows prediction of the overall characteristics of thrust systems employing electron-bombardment ion thrusters Elements of the thrust system are defined and their characteristics presented in a parametric fashion. Two system approaches are evaluated where power management and control elements and thruster characteristics were substantially different. For an assumed system approach, the methodology presented predicts overall system properties, such as input power and mass, when major mission and thrust

system parameters, such as trip time and specific impulse, are assumed Author

N79-22191\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

RESULTS FROM SYMPOSIUM ON FUTURE ORBITAL POWER SYSTEMS, TECHNOLOGY REQUIREMENTS

Soi Gorland 1979 8 p refs To be presented at the 14th Intersoc. Energy Conversion Eng. Conf., Boston, 5-10 Aug. 1979: sponsored by the Am. Chem. Soc.

(NASA-TM-79125; E-9961) Avail NTIS HC A02/MF A01 CSCL 10B

The technology requirements for future orbital power systems were reviewed. Workshops were held in 10 technology disciplines to discuss technology deficiencies, adequacy of current programs to resolve those deficiencies and recommendations for tasks that might reduce the testing and risks involved in future orbital energy systems. Those recommendations are summarized J.M.S.

N79-22192\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

INCREASED CAPABILITIES OF THE 30-cm DIAMETER Hg ION THRUSTER

Vincent K. Rawlin and Charles E. Hawkins 1979 22 p refs Presented at the Conf. on Advanced Technol. for Future Space Systems, Lang'sy, Va., 8-11 May 1979; spunsored by AIAA (NASA-TM-79142; E-9995) Avail: NTIS HC A02/MF A01

Some space flight missions require advanced ion thrusters which operate at conditions much different than those for which the baseline 30-cm Hg thruster was developed. Results of initial tests of a 30-cm Hg thruster with two and three grid ion accelerating systems, operated at higher values of both thrust and power and over a greater range of specific impulse than the baseline conditions are presented. Thruster lifetime at increased input power was evaluated both by extended tests and real time spectroscopic measurements.

N79-22193°# National Aeronautics and Space Administration. Lewis Research Center, Claveland, Ohio.

AN ECONOMIC ANALYSIS OF A COMMERCIAL AP-PROACH TO THE DESIGN AND FABRICATION OF A SPACE POWER SYSTEM

Zimri Putney (Solarex Corp., Rockville, Md.) and Julian Been 1979 8 p refs Presented at the Conf on Adv. Technol. for Future Space Systems, Hampton, 8-11 May 1979; sponsored by AIAA

(NASA-TM-79153; E-1009) Avail NTIS HC A02/MF A01 CSCL 10A

A commercial approach to the design and fabrication of an economical space power system is presented. Cost reductions are projected through the conceptual design of a 2 kW space power system built with the capability for having serviceability. The approach to system costing that is used takes into account both the constraints of operation in space and commercial production engineering approaches. The cost of this power system reflects a variety of cost/benefit tradeoffs that would reduce system cost as a function of system reliability requirements. complexity, and the impact of rigid specifications. A breakdown of the system design, documentation, fabrication, and reliability JMS and quality assurance cost astimates are detailed

N78-23132°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF LOW-STIFFNESS CLOSEOUT OVERWRAP ON ROCKET THRUST-CHAMBER LIFE

Harold J. Kasper and J. Joseph Nota-donato May 1979 23 p refs

'NASA-TP-1456, E-9870) Avail NTIS HC A03/MF A01 CSCL

Three rocket thrust chambers with copper liners and a thrust level of 20.9 kN were cyclically test fired to failure. Two of the liners were made from oxygen free, high conductivity (OFHC) copper and from annealed Arnzirc. The milled coolant channels were closed out with a thin copper closeout over which a fiberglass composite was wrapped to provide hoop strength only. Experimental data are presented, along with the results of a preliminary analysis that was performed before fabrication to evaluate the life extending potential of a thin copper closeout with a fiberglass overwrap

N79-23133\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE ROLE OF FUEL CELLS IN NASA'S SPACE POWER SYSTEMS

Julian F. Been 1979 11 p refs To be presented at the 14th Energy Conversion Eng. Conf., Boston, 5-10 Aug. 1979 (NASA-TM-79182; E-042) Avail: NTIS HC A02/MF A01 CSCL 22B

A history of the fuel cell technology is presented and compared with NASA's increasing space power requirements. The role of fuel cells is discussed in perspective with other energy storage systems applicable for space using such criteria as type of mission. weight, reliability, costs, etc. Potential applications of space fuel cells with projected technology advances were examined. S.E.S.

N79-25131°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

THE 30-CENTIMETER ION THRUST SUBSYSTEM DESIGN MANUAL

Jun. 1979 579 p refs

(NASA-TM-79191, E-060) Avail NTIS HC A25/MF A01 CSCL

The principal characteristics of the 30-centimeter ion propulsion thrust subsystem technology that was developed to satisfy the propulsion needs of future planetary and early orbital missions are described. Functional requirements and descriptions. interface and performance requirements, and physical characteristics of the hardware are described at the thrust subsystem, BIMOD engine system, and component level

N79-28220\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PLANS FOR SPACE COMMUNICATION TECHNOLOGY

Robert E. Alexovich 1979 13 p. refs. Proposed for presentation at EASCON Session on Communications Satellite Technol. Washington, D. C. 9-11 Oct. 1979, sponsored by IEEE (NASA-TM-79217 E-107) Avail NTIS HC A02/MF A01 CSCL

A program plan is presented for a space communications application utilizing the 30/20 GHz frequency bands (30 GHz uplink and 20 GHz downlink) Results of market demand studies and spacecraft systems studies which significantly affect the supporting research and technology program are also presented, along with the scheduled activities of the program Author

N79-30290° National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

CHARACTERISTICS OF PRIMARY ELECTRIC PROPULSION SYSTEMS

David C. Byers 1979 17 p refs Proposed for Presentation at 14th Intern. Conf. on Elec Propulsion, Princeton, N. J., 31 Oct. - 2 Nov 1979, sponsored by AIAA and GLR (NASA-TM-79255: E-166) Avail NTIS HC A02/MF A01 CSCL 21C

The use of advanced electric propulsion systems is expected to provide cost and performance benefits for future energetic space missions. A methodology to predict the characteristics of advanced electric propulsion systems was developed and programmed for computer calculations to allow evaluation of a broad set or technology and mission assumptions. The impact on overall thrust system characteristics was assessed for variations

AN ASSESSMENT OF THE

of propellant type, total accelerating voltage, thruster area, specific impulse, and power system approach. The data may be used both to provid's direction to technology emphasis and allow for preliminary estimates of electric propulsion system properties for a wide variety of applications.

Author

N79-31343°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

SPUTTERING IN MERCURY ION THRUSTERS

Maris A. Mantenieks and Vincent K. Rawlin. 1979. 20 p. refs. Prosented at 14th Intern. Conf. on Electric Propulsion, Princeton, N. J., 31 Oct. - 2 Nov. 1979; sponsored by AIAA and Deutsche Gesselschaft für Luft-und Raumfahrt.

(NASA-TM-79266; E-181) Avail: NTIS HC A02/MF A01 CSCL 21C

A model, which assumes that chemisorption is the dominant in chanism, is applied to the sputtering rate measurements of the screen grid of a 30 cm thruster in the presence of nitrogen. The model utilizes inputs from a variety of experimental and analytical sources. The model of environmental effects on sputtering was applied to thruster conditions of low discharge voltage and a discussion of the comparison of theory and experiment is presented.

M.M.M.

N79-33252\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio

SERT 2 1979 EXTENDED FLIGHT THRUSTER SYSTEM PERFORMANCE

W. R. Kerslake and L. R. Ignaczak. 1979. 22 p. refs. Presented at 14th Intern. Conf. on Electric Propulsion, Princeton, N. J. 31 Oct. - 2 Nov. 1979, sponsored by AIAA and Deutsche Gesselschaft füer Luft- und Raumfahrt.

(NASA-TM-79256, E-168, AIAA-Paper-79-2063) Avail NTIS HC AO2/MF AO1 CSCL 21H

Steady state tests of the thruster 2 system on the SERT 2 spacecraft are presented. A direct thrust measurement was obtained for the ion thruster during operations to increase the spacecraft pin rate to maintain spacecraft attitude stability. The continued restart tests of thruster 1 and a report on the general status of all spacecraft systems including the main solar array are presented.

N79-33253\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

REDUCED POWER PROCESSOR REQUIREMENTS FOR THE 30-cm DIAMETER Hg ION THRUSTER

Vincent K. Rawlin 1979 14 p. refs. Presented at the 14th Intern. Conf. on Electric Propulsion. Princeton. N. J. 30 Oct. - 1. Nov. 1979. sponsored by AIAA and Deutsche Gesselschaft füer Luft- und Raumfahrt.

(NASA-TM-79257 E-169 AIAA-Paper-79-2081) Avail NTIS HC A02/MF A01 CSCL 21C

An evaluation of simplifications for the thruster power processor interface for a 30 cm Hg ion thruster is presented. Tests on the engine, thruster control, and the power supplies are performed. Reduced power processors requirements are defined and the impact on thruster Jesign, performance, and lifetime are assessed.

A W H

N79-33254\*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

PRELIMINARY RESULTS OF THE MISSION PROFILE LIFE TEST OF A 30 cm Hg BOMBARDMENT THRUSTER

R T Bechtel and E. L. James (Xirox-EOS. Pasadena, Calif.) 1979—23 p. refs. Presented at 14th Intern. Conf. on Electric Propulsion Princeton, N. J., 31 Oct. - 2 Nov. 1979—sponsored by AIAA and Deutsche Gesselschaft füer Luft—und Raumfahrt (NASA-TM-79261, E-175). Avail. NTIS. H.C. A02/MF. A01. CSCL. 200.

Long term tests were performed on a 30 cm Hg bombardment thruster and a power processing unit to determine lifetime characteristics. The thruster performance data and other operational characteristics taken at various times during the test segment are presented and evaluated with the life limiting mechanisms discharge chamber erosion, deposition and spalling. external erosion, cathode degradation, and propellant isolator leakage. The control algorithms for thruster start up, steady state operation, throttle, detection and correction of off normal conditions, and shutdown are discussed.

A W H

N79-33255\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NEUTRALIZATION TESTS ON THE SERT 2 SPACECRAFT William R Kerslake and Stanley Domitz 1979 24 p refs Presented at 14th Intern. Conf. on Electric Propulsion, Princeton. N J., 31 Oct. - 2 Nov. 1979. sponsored by AIAA and Deutsche Gesselschaft fuer Luft- und Raumfahrt

(NASA-TM-79271; E-191; AIAA-Paper-79-2064; Avail NTIS HC AO2/MF AO1 CSCL 22B

Neutralization test data obtained on the SEFT 2 spacecraft are presented. Tests included ion beam neutralization of a thruster by a close (normal design) neutralizer as well as by a distant (1 meter) neutralizer Parameters affecting neutralization, such as neutralizer bias voltage, neutralizer anode voltage, local spacecraft plasma density, and solar array voltage configuration were varied and changes in plasma potentials were measured A plasma model is presented as an approximation of observed results.

A79-10014 \* Status of wraparound contact solar cells and arrays. C. R. Baraona (NASA, Lewis Research Center, Cleveland, Ohio) and L. E. Young (NASA, Marshall Space Flight Center, Huntsville, Ala.). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings. Volume 1. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 84-90, 13 refs.

The paper describes the development of wraparound contact solar cell technology. Future development trends are distinguished. The current method of module fabrication with wraparound contact cells is briefly reviewed. The prospects for automated cell assembly are discussed.

P. T.H.

A79-34704 \* Space propulsion technology overview. J. J. Pelouch, Jr. (NASA; Lewis Research Center, Propulsion Systems Section, Cleveland, Ohio). In: Conference on Advanced Technology for Future Space Systems, Hampton, Va., May 8-10, 1979, Technical Papers. (A79-34701 14-12). New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 24-29. (AIAA 79-0860).

This paper discusses Shuttle-era, chemical and electric propulsion technologies for operations beyond the Shuttle's orbit with focus on future mission needs and economic effectiveness. The adequacy of the existing propulsion state-of-the-art, barriers to its utilization, benefit of technology advances, and the prognosis for advancement are the themes of the discussion. Low-thrust propulsion for large space systems is cited as a new technology with particularly high benefit. It is concluded that the Shuttle's presence for at least two decades is a legitimate basis for new propulsion technology, but that this technology must be predicated on an awareness of mission requirements, economic factors, influences of other technologies, and real constraints on its utilization. (Author)

A79-34736 \*\* Some effects of cyclic induced deformation in rocket thrust chambers. N. P. Hannum, R. J. Quentmeyer, and H. J. Kasper (NASA, Lewis Research Center, Cleveland, Ohio). In Conference on Advanced Technology for Future Space Systems, Hampton, Va., May 8 10, 1979, Technical Papers. (A79-34701 14-12) New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 290-299, 8 refs. (AIAA 79-0911)

A test program to investigate the deformation process observed in the hot gas wall of rocket thrust chambers was conducted using three different liner materials. Five thrust chambers were cycled to failure using hydrogen and oxygen as propellants at a chamber pressure of 4.14 MN/sp m. The everymenton was observed nonde structively at midlife points and destructively after failure occurred. The cyclic life results are presented with an accompanying discussion.

about the types of failure encountered. Data indicating the deformation of the thrust chamber liner as cycles are accumulated are presented for each of the test thrust chambers. (Author)

A79-34737 \* # An economic analysis of a commercial approach to the design and fabrication of a space power system. Z. Putney (Solarex Corp., Rockville, Md.) and J. Been (NASA, Lewis Research Center, Cleveland, Ohio). In: Conference on Advanced Technology for Future Space Systems, Hampton, Va., May 8-10, 1979, Technical Papers. (A79-34701 14-12) New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 300-305. 6 refs. (A1AA 79-0914)

This paper discusses a commercial approach to the design and fabrication of an economical space power system. With the advent of the space shuttle, steps can be taken to back away from the presently used space qualified approach in order to reduce cost of space hardware by incorporating, where possible, commercial design, fabrication, and quality assurance methods. Cost reductions are projected through the conceptual design of a 2 kW space power system built with the capability for having serviceability. The approach to system costing that has been used takes into account both the constraints of operation in space and commercial production engineering approaches. The cost of this power system reflects a variety of cost/benefit tradeoffs that would reduce system cost as a function of system reliability requirements, complexity, and the impact of rigid specifications. A breakdown of the system design, documentation, fabrication and reliability and quality assurance cost estimates are detailed.

A79-34773 \* # Primary electric propulsion for future space missions. D. C. Byers, F. F. Terdan, and I. T. Myers (NASA, Lewis Research Center, Cleveland, Ohio). In: Conference on Advanced Technology for Future Space Systems, Hampton, Va., May 8-10. 1979, Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1979. 43 p. 27 refs. (AIAA 79-0881)

The paper presents data and a methodology to allow preliminary definition of electric propulsion systems. The elements comprising the thrust system are described parametrically. As an example, thruster performance is presented as a function of specific impulse and propellant type. Two power management and control (PMAC) approaches are considered to illustrate the use of the methodology. Power source characteristics are disregarded in the system description. One PMAC concept assumes a do power input to the thrust system and all thruster power conditioned in a conventional manner; the other PMAC approach assumes an ac power source.

S.D.

A79-34774 \* Increased capabilities of the 30-cm diameter Hg ion thruster. V. K. Rawlin and C. E. Hawkins (NASA, Lewis Research Center, Cleveland, Ohiol. In: Conference on Advanced Technology for Future Space Systems, Hampton, Va., May 8-10, 1979, Technical Papers. New York, American Institute of Aerotics and Astronautics, Inc., 1979, 20 p. 21 refs. (AIAA 79-0910)

A 30-cm-diam mercury ion thruster, using two or three grid ion accelerating systems, is operated at increased values of beam current. Comparisons with the SEP (Solar Electric Propulsion) and EPSEP (Extended Performance SEP) baseline thrusters are made with respect to performance and lifetime. It is found that when a third, or decelerator, grid is added to the conventional two-grid optics of a SEP like thruster, the ion beam focusing properties are improved, as expected from theoretical considerations. The total thruster efficiency as a function of specific impulse, is increased for values of specific impulse in the range 1200-2800 sec. Lifetime test results predict a thruster lifetime, under space conditions, not less than that of the baseline SEP thruster:

S.D.

A79-34775 \* # Lerge space system - Charged particle environment interaction technology. N. J. Stevens, J. C. Roche, and N. T. Grier (NASA, Lewis Research Center, Cleveland, Ohio). In. Conference on Advanced Technology for Future Space Systems, Hampton, Va., May 8-10, 1979, Technical Papers. New York American Institute of Aeronautics and Astronautics, Inc., 1979. 21 p. 31 refs. (AIAA 79-0913)

Large high-voltage space power systems proposed for future applications in both low earth orbit and geosynchronous altitudes must operate in the space charged-particle environment with possible interactions between this environment and the high-voltage surfaces. The paper reviews the ground experimental work to provide indicators for the interactions that could exist in the space power system. A preliminary analytical model of a large space power system is constructed using the existing NASA Charging Analyzer Program, and its performance in geosynchronous orbit is evaluated. The analytical results are used to illustrate the regions where detrimental interactions could exist and to establish areas where future technology is required.

A79-38972 \* # Plug cluster engine concept for in-space missions. C. J. O'Brien (Aerojet Liquid Rocket Co., Sacramento, Calif.) and C. A. Aukerman (NASA, Lewis Research Center, Cleveland, Ohio). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1179. 10 p. 27 refs.

The development of a suitable orbital transfer vehicle (OTV) engine is discussed. The OTV's dimensions are limited by those of the Space Shuttle payload bay on which it will be carried. An approach to utilize the available diameter to achieve high area ratio and thus high engine performance, is presented. Unconventional nozzles, such as clusters of small thrusters around a large diameter contoured plug, are investigated to arrive at engine designs which feature lower chamber pressures, with attendant lower heat flux, lower wall temperature, longer fatigue life, and less critical turbomachinery. Attention is also given to plug nozzle technology, high area ratio module: and scarfed bell- Plug Cluster Engine (PCE) concepts, as well as PCE performance, weight, and assessment. A conceptual design of a PCE formed from a cluster of high area ratio, scarfed, bell nozzles proved to be competitive with bell and spike nozzle engines. PCE advantages cited include increased payload length due to shorter engine length, ability to increase or decrease the number of modules and thereby the thrust, and low cost due to utilization of off-the-shelf technology.

A79-39815 \* ... Low-thrust chemical orbit transfer propulsion, J. J. Pelouch, Jr. (NASA, Lewis Research Center, Space Propulsion and Power Div., Cleveland, Ohio). AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1182. 20 p.

The need for large structures in high orbit is discussed in terms of the many mission opportunities which require such structures. Mission and transportation options for large structures are presented, and it is shown that low-thrust propulsion is an enabling requirement for some missions and greatly enhancing to many othe s. A general comparison of electric and low-thrust chemical propulsion is made and the need for and requirements of low-thrust chemical propulsion are discussed in terms of the interactions that are perceived to exist between the propulsion system and the large structure. (Author)

A79-40984 \* # Preliminary evaluation of glass resin materials for solar cell cover use. S. J. Marsík, C. K. Swartz, and C. R. Baraona (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. (A79-40881 17-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 624-627.

Silicon solar cells and silicon wafers coated with a heat-curable resin consisting of alternating Si-O atoms were subjected to three tests to evaluate the potential utility of this coating in space

environments. These included UV irradiation in vacuum at an intensity of 10 air mass zero UV energy-equivalent solar constants for 728 hours followed by a long thermal cycle; 15 thermal shock cycles between 100 C and minus 196 C; and high temperature and humidity (65 C at 90% relative humidity). The UV tests resulted in a 8 to 24% loss in short-circuit current and darkening of the covers. Modification of the resin to provide a better match between the coefficients of expansion of the resin and silicon improved resistance to thermal shock, but also increased the darkening effect under UV irradiation. Silicon wafers coated with the resin were not adversely affected by the temperature/humidity test.

C.K.D.

A79-51810 \* # The role of fuel cells in NASA's space power systems. J. F. Been (NASA, Lewis Research Center, Cleveland, Ohio). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings. Volume 1. (A79-51720-23-44) Washington, D.C., American Chemical Society, 1979, p. 544-549, 11 refs.

The advances in fuel cell technology which have expanded the capabilities of the fuel cell from that of power generation to include energy storage also expanded its potential role in space power systems. This paper presents a brief evolutionary history of the fuel cell technology and compares this with NASA's increasing space power requirements. The role of fuel cells is put in perspective with other energy storage systems applicable for space using such criteria as type of mission, weight, reliability, costs, etc. Potential applications of space fuel cells with projected technology advances are examined. (Author)

N79-10120\* Xerox Electro Optical Systems, Pasadena, Calif Electronic Systems Div

INERT GAS ION SOURCE PROGRAM Final Report, 2 Mar. 1977 - 2 Jan. 1978

William D Ramsey 13 Jul 1978 76 p refs

(Contract NAS3-20393)

(NASA-CR-159423. XEOS-2361) Avail NTIS

HC A05/MF A01 CSCL 21C

The original 12 cm hexagonal magneto-electrostatic containment discharge chamber has been optimized for argon and xenon operation. Argon mass utilization efficiencies of 65 to 77 percent were achieved at keeper-plus-main discharge energy consumptions of 200 to 458 eV/ion, respectively. Xenon performance of 84 to 96 percent mass utilization was realized at 203 to 350 eV/ion. The optimization process and test results are discussed.

N79 11115\*# Battelle Pacific Northwest Labs Richard Wash DEVELOPMENT OF SPUTTERING PROCESS TO DEPOSIT STOICHIOMETRIC ZIRCUNIA COATINGS FOR THE INSIDE WALL OF REGENERALIVELY COOLED ROCKET THRUST CHAMBERS

R Busch 19 Jul 1978 33 p refs

Contract NAS3 197211

(NASA CR 159412) Avail NTIS HC A03 MF A01 CSCL

Thermal barrier coatings of yttria stabilized zirconia and zirconia ceria mixtures were deposited by RF reactive sputtering. Coatings were 1.2 mils thick and were deposited on copper cylinders intended to simulate the inner wall of a regeneratively cooleit thrust chamber. Coating stoichiometry and adherence were investigated as functions of deposition parameters. Modest deposition rates improximately 0.15 mil hill and subambient sustrate temperatures. 1.80 Cl. resulted in nearly stoichiometric roatings which remained adherent through thermal cycles between 196 and 400 C. Coatings deposited at higher rates or substrates temperatures exhibited greater oxygen deficiences while soatings deposited at lower temperatures were not adherent. Substrate thas resulted in structural changes in the coating and high krypton contents no clear effect on stoichiometry was observed.

N79-14153\*# Hughes Research Labs., Malibu, Calif. Ion Physics Dept.

ADVANCED ELECTROSTATIC ION THRUSTER FOR SPACE PROPULSION Final Report, 21 May 1976 - 21 Jan. 1978
Tommy D. Masek, Duncan MacPherson, Walter Gelon, Seiji Kami, Robert L. Poeschel, and James W. Ward Apr. 1978 400 p

(Contract NAS3-20101)

(NASA-CR-159406) Avail: NTIS HC A17/MF A01 CSCL 21C

The suitability of the baseline 30 cm thruster for future space missions was examined. Preliminary design concepts for several advanced thrusters were developed to assess the potential practical difficulties of a new design. Useful methodologies were produced for assessing both planetary and earth orbit missions. Payload performance as a function of propulsion system technology level and cost sensitivity to propulsion system technology level are among the topics assessed. A 50 cm diameter thruster designed to operate with a beam voltage of about 2400 V is suggested to satisfy most of the requirements of future space missions.

N79-1515€<sup>1</sup># Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering

PREDICTION OF PLASMA PROPERTIES IN MERCURY ION THRUSTERS

Glen Longhurst Dec 1978 118 p refs

(Grant NGR-06-002-112)

(NASA-CR-159448) Avail NTIS HC A06/MF A01 CSCL

A simplified theoretical model was developed which obtains to first order the plasma properties in the discharge chamber of a mercury ion thruster from basic thruster design and controllable operating parameters. The basic operation and design of ion thrusters is discussed, and the important processes which influence the plasma properties are described in terms of the design and control parameters. The conservation for mass, charge and energy were applied to the ion production region, which was defined as the region of the discharge chamber having as its outer boundary the surface of revolution of the innermost field line to intersect the anode. Mass conservation and the equations describing the various processes involved with mass addition and removal from the ion production region are satisfied by a Maxwellian electron density spatial distribution in that region.

B B

N79-16913\*# Colorado State Univ. Fort Collins Dept of Mechanical Engineering
MERCURY ION THRUSTER RESEARCH, 1978
Annual Report, 1 Dec. 1977 - 1 Dec. 1978
Paul J Wilbur Dec 1978 110 p refs
(Grant NGR-06-002-112)
(NASA-CR-159485) Avail NTIS HC A06/MF A01 CSCL

The effects of 8 cm thruster main and neutralizer cathode operating conditions on cathode orifice plate temperatures were studied. The effects of cathode operating conditions on insert temperature profiles and keeper voltages are presented for three different typus of inserts. The bulk of the emission current is generally observed to come from the downstream end of the insert rather than from the cathode orifice plate. Results of a test in which the screen grid plasma sheath of a thruster was probed as the beam current was varied are shown. Grid performance obtained with a grid machined from glass ceramic is discussed. The effects of copper and nitrogen impurities on the sputtering rates of thruster materials are measured experimentally and a model describing the rate of nitrogen chemisorption on materials in either the beam or the discharge chamber is presented. The results of optimization of a radial field thruster design are presented Performance of this device is shown to be comparable to that of a divergent field thruster and efficient operation with the screen grid biased to floating potential, where its susceptibility to sputter erosion damage is reduced, is demonstrated

N79-19073\*# Lockheed Missiles and Space Co., Huntsville, Ala Research and Engineering Center.

STRUCTURAL ANALYSIS OF CYLINDRICAL THRUST CHAMBERS, VOLUME 1 Final Report, May 1978 - Mar. 1979

W. H. Armstrong Mar 1979 52 p refs (Contract NAS3-21361)

(NA SA - CR 159522, LMSC-HREC-TR-D568827-Vol-1) Avail. NTIS HC A04/MF A01 CSCL 21H

Life predictions of regeneratively cooled rocket thrust chambers are normally derived from classical material fatigue principles. The failures observed in experimental thrust chambers do not appear to be due entirely to material fatigue. The chamber coolant walls in the failed areas exhibit progressive bulging and thinning during cyclic firings until the wall stress finally exceeds the material rupture stress and failure occurs. A preliminary analysis of an oxygen free high conductivity (OFHC) copper cylindrical thrust chamber demonstrated that the inclusion of cumulative cyclic plastic effects enables the observed coolant wall thinout to be predicted. The thinout curve constructed from the referent analysis of 10 firing cycles was extrapolated from the tenth cycle to the 200th cycle. The preliminary OFHC copper chamber 10-cycle analysis was extended so that the extrapolated thinout curve could be established by performing cyclic analysis of deformed configurations at 100 and 200 cycles. Thus the original range of extrapolation was reduced and the thinout curve was adjusted by using calculated thinout rates at 100 and 100 cycles. An analysis of the same underformed chamber model constructed of half-hard Amzirc to study the effect of material properties on the thinout curve is included

#### N79-19074\*# Aerojet Liquid Rocket Co. Sacramento, Calif ADVANCED ENGINE STUDY FOR MIXED-MODE ORBIT-TRANSFER VEHICLES Final Report

J. A Mellish Dec 1978 228 p refs (Contract NAS3-21049)

(NASA-CR-159491) Avail NTIS HC A11/MF A01 CSCL 21H

Engine design, performance, weight and envelope data were established for three mixed-mode orbit-transfer vehicle engine candidates Engine concepts evaluated are the tripropellant. dual-expander and plug cluster Oxygen, RP-1 and hydrogen are the propellants considered for use in these engines. Theoretical performance and propellant properties were established for bipropellant and tripropellant mixes of these propellants RP-1. hydrogen and oxygen were evaluated as coolants and the maximum attainable chamber pressures were determined for each engine concept within the constraints of the propellant properties and the low cycle thermal fatigue (300 cycles) requirement. The baseline engine design and component operating characteristics are determined at a thrust level of 88,964N (20,000 lbs) and a thrust split of 0.5. The parametric data is generated over ranges of thrust and thrust split of £6.7 to 400kN (15 to 90 klb) and ARH 0.4 to 0.8 respectively

N79-26110\*# Colorado State Univ Fort Collins Dept of Mechanical Engineering

INERT GAS THRUSTERS Annual Report Harold R Kaufman Nov 1978 88 p refs (Grant NsG-3011)

INASA CR 1595271 Avail NTIS HC A05/MF A01 CSCL 21H

Inert gas thrusters have continued to be of interest for space propulsion applications. Xenon is of interest in that its physical characteristics are well suited to propulsion. High atomic weight and low tankage fraction were major factors in this choice. If a large amount of propellant was required so that cryogenic storage was practical argon is a more economical alternative. Argon was also the preferred propellant for ground applications of thruster technology, such as sputter etching and deposition. Additional magnetic field measurements are reported. These measurements should be of use in magnetic field design. The diffusion of electrons through the magnetic field above multipole anodes was studied in detail. The data were consistent with Bohm diffusion across a magnetic field. The theory based on Bohm diffusion was simple and easily used for diffusion calculations. Limited startup data

were obtained for multipole discharge chambers. These data were obtained with refractory cathodes, but should be useful in predicting the upper limits for starting with hollow cathodes.

J.A.M.

N79-28224\*# Aerojet Liquid Rocket Co., Sacramento, Calif UNCONVENTIONAL NOZZLE TRADEOFF STUDY C. J. OBrien Jul. 1979 311 p refs

(Contract NAS3-20109)

(NASA-CR-159520) Avail NTIS HC A14/NF A01 CSCL 21H Plug cluster engine design, performance, weight, envelope, operational characteristics, development cost, and payload capability, were evaluated and comparisons were made with other space tug engine candidates using oxygen/hydrogen propellants. Parametric performance data were generated for existing developed or high technology thrust chambers clustered around a plug nozzle of very large diameter. The uncertainties in the performance prediction of plug cluster engines with large gaps between the modules (thrust chambers) were evaluated The major uncertainty involves, the aerodynamics of the flow from discrete nozzles, and the lack of this flow to achieve the pressure ratio corresponding to the defined area ratio for a plug cluster This uncertainty was reduced through a cluster design that consists of a plug contour that is formed from the cluster of high area ratio bell nozzles that have been scarfed. Light-weight, high area ratio, bell nozzles were achieved through the use of AGCarb (carbon-carbon cloth) nozzle extensions

#### N79-31341°# Sundstrand Corp., Rockford, III LIQUID OMYGEN/LIQUID HYDROGEN BOOST/VANE PUMP FOR THE ADVANCED ORBIT TRANSFER VEHICLES AUXILIARY PROPULSION SYSTEM

F. Gluzek, R. G. Mokadam, I. H. To, J. D. Stanitz, and J. Wollschlager. Sep. 1979. 138 p. refs. (Contract NAS3-20401)

(NASA-CR-159648) Avail NTIS HC A07/MF A01 CSCL 21H

A rotating positive displacement vane pump with an integral boost stage was designed to pump saturated liquid oxygen and liquid hydrogen for auxiliary propulsion system of orbit transfer vehicle. This unit is designed to ingest 10% vapor by volume, contamination free liquid oxygen and liquid hydrogen. The final pump configuration and the predicted performance are included. A W.H.

A79-22396 \* Convective heat flux in a laser-heated thruster. P. K. S. Wu (Physical Sciences, Inc., Woburn, Mass.). *Journal of Spacecraft and Rockets*, vol. 16, Jan. Feb. 1979, p. 56-58, 7 refs. Contract No. NAS3-19728.

A79-51907 \* Hydrogen recombination in sealed mickel-cadmium aerospace cells. P. F. Bitterman (TRW Defense and Space Systems Group, Redondo Beach, Calif.). In Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass. August 5-10, 1979. Proceedings. Volume 2. (A79-51726-23-44) Washington, D.C., American Chemical Society, 1979, p. 1288-1291. Contract No. NAS3-21253.

The paper presents a mechanism which offers in explanation of the observed behavior of nickel-cadmium cells during voltage reversal. Constant current reversals using aerospace Ni-Cd cells showed that at rates of C/100 and temperatures of 20 C, a steady condition of constant pressure is achieved with continuous overdischarge. Results of a test employing a battery pack of thirteen 24 Ah cells at 10 C showed that: (1) no net evolution of H occurs in Ni-Cd cells during overdischarge, (2) as H pressure increases the rate of pressure rise decreases, and (3) after attaining pressure equilibrium at a given overdischarge rate, a pressure decrease is noted when the discharge is lowered. Other tests using varying overdischarge rates were examined and have resulted in the development of a laboratory cell with a safe overdischarge capability of C/20 which is three times as great as state-of-the-art Ni-Cd cells.

C.F.W.

A79-51911 \* Some practical observations on the accelerated testing of Nickel-Cadmium Cells. P. P. McDermott (Coppin State College, Baltimore, Md.). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings. Volume 2. (A79-51726-23-44) Washington, D.C., American Chemical Society, 1979, p. 1305-1309, 12 refs. Grant No. NsG-5051.

A large scale test of 6.0 Ah Nickel-Cadmium Cells conducted at the Naval Weapons Support Center, Crane, Indiana has demonstrated a methodology for predicting battery life based on failure data from cells cycled in an accelerated mode. After examining eight variables used to accelerate failure, it was determined that temperature and depth of discharge were the most reliable and efficient parameters for use in accelerating failure and for predicting life. (Author)

### 23 CHEMISTRY AND MATERIALS (GENERAL)

Includes biochemistry and organic chemistry.

N79-11119\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

A STUDY OF VARIOUS SYNTHETIC ROUTES TO PRODUCE A HALOGEN-LABELED TRACTION FLUID

William R. Jones, Jr. and Hans Zimmer Nov. 1978 10 p. refs. (NASA-TM-79024, E-9821) Avail NTIS HC A02/MF A01

Several synthetic routes were studied for the synthesis of the compound 1, 1, 3-trimethyl-1, 3-dicyclohexyl-2 chloropropane This halogen-labeled fluid would be of use in the study of high traction lubricants under elastohydrodynamic lubrication conditions using infrared emission spectroscopy. The synthetic routes included dimerization of alpha-methylstyrene, methanol addition to alpha-methylstyrene, a Wittig reaction, and an organometallic approach Because of steric hindrance and competing reactions. none of these routes were successful

N79-21128°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THREE METHODS FOR IN SITU CROSS-LINKING OF POLYVINYL ALCOHOL FILMS FOR APPLICATION AS ION-CONDUCTING MEMBRANES IN POTASSIUM HY-DROXIDE ELECTROLYTE

Warren H. Philipp and Li-Chen Hsu Apr. 1979 18 p refs (NASA-TP-1407: E-9778) Avail NTIS HC A02/MF A01 CSCL 07 D

Three methods of in situ cross-linking polyvinyl alcohol films are presented. They are (1) acetalization with a dialdehyde such as glutaraldehyde. (2) acetalization with a dehyde groups formed by selective oxidative cleaving of the few percent of 1.2 diol units present in polyvinyl alcohol, and (3) cross-linking by hydrogen abstraction by reaction with hydrogen atoms and hydroxyl radicals from irradiated water. For the third method, improvement in film conductivity in KOH solution at the expense of mechanical strength is obtained by the presence of polyacrylic acid in the polyvinyl alcohol films. Resistivities in 45 percent KOH are given for in situ cross-linked films prepared by each of the three methods Author

N79-22194\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

IMPROVED ADHERENCE OF SPUTTERED TITANIUM CARBIDE COATINGS ON NICKEL AND TITANIUM-BASE ALLOYS

Donald R Wheeler and William A Brainard Apr 1979 18 p

(NASA-TP-1450 E-9838) Avail NTIS HC A02/MF A01 CSCL

Rene 41 and Ti-6Al-4V alloys were radio frequency sputter coated with titanium carbide by several techniques in order to determine the most effective Coatings were evaluated in pin-on-disk tests. Surface analysis by X-ray photoelectron spectroscopy was used to relate adherence to interfacial chemistry For Rene 41, good coating adherence was obtained when a small amount of acetylene was added to the sputtering plasma The acetylene carburized the alloy surface and resulted in better bonding to the TiC coating For Ti-6Al-4V, the best adherence and wear protection was obtained when a pure titanium interlayer was used between the coating and the alloy. The interlayer is thought to prevent the formation of a brittle. fracture-prone aluminum oxide layer Author

N79-24081°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FOLYIMIDE PREPREG MATERIAL HAVING IMPROVED TACK RETENTION Patent Application

T. T. Serafini and P. Deluigs, inventors (to NASA) Filed 6 Apr. 1979 10 p

(NASA-Case-LEW-12933-1; US-Patent-Appl-SM 027557) Avail: NTIS HC A02/MF A01 CSCL 070

A composition, of the type disclosed in U.S. Paterit 3.745,149 and which includes a polyfunctional ester, a polyfunctional amine, and an end-capping agent, is impregnated into fibers or fabric and heated to form prepreg material. The tack retention characteristics of this prepreg material are improved by incorporating into the composition a liquid olefinic material compatible with the other ingredients of the composition. The prepreg material is heated at a higher temperature to effect formation of the polyimide rasin and the monomeric additive is incorporated in NASA the polyimide polymer structure.

N79-27242\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ELECTROCHEMICAL FLUORINATION OF TRICHLOROETH-YLENE AND N. N-DIMETHYLTRIFLUOROACETAMIDE Li-chen Hair 1979, 14 p. refs. Presented at the 155th Meeting of the Electrochem. Soc., Boston, 6-11 May 1979

(NASA-TM-79188: E-057) Avail NTIS HC A02/MF A01 CSCL 07C Fluorination of trichloroethylene and

methyltrifluoroacetamide was carried out on a laboratory scale in an advanced Simons type electrochemical apparatus which could be operated automatically from ambient to 50 psi pressure. A variety of fluorine-substituted products are formed, depending upon electrolysis conditions and concentrations of reactant relative to the NaF, KF, HF electrolyte. A new reaction mechanism of electrochemical fluorination of trichloroethylene is proposed. The solvency-to-fluorine content relationship of fluorinated N. N-dimethyltrifluoroacetamide is described. Author

N79-31345\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

**CURING AGENT FOR POLYEPOXIDES AND EPOXY RESINS** AND COMPOSITES CURED THEREWITH Patent Application

T. T. Serafini and P. Delvigs, inventors (to NASA) Filed 30 Aug 1979 14 p

(NASA-Case-LEW-12226-1, US-Patent-Appl-SN-070771) Avail NTIS HC A02/MF A01 CSCL 07C

A curing agent for a polyepoxide is described which contains a divalent aryl radical such as phenylene and a tetravalent aryl radical such as a tetravalent benzene radical. An epoxide is cured by admixture with the curing agent. The cured epoxy product retains the usual properties of cured epoxides and, in addition, has a high char residue after burning, on the order of 45% by weight. The high char residue is of value in preventing release to the atmosphere of carbon fibers from carbon fiber-epoxy resin composites in the event of burning of the composite

N79-31346\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SURFACE CHEMISTRY OF IRON SLIDING IN AIR AND NITROGEN LUBRICATED WITH HEXADECANE AND HEXADECANE CONTAINING DIBENZYL-DILSULFIDE

Donald R Wheeler Sep 1979 15 p refs

(NASA-TP-1545, E-9956) Avail NTIS HC A02/MF A01 CSCL 11G

Wear experiments were conducted on iron sliding in hexadecane and hexadecane plus one weight percent dibenzyl dilsulfide (DBDS) in atmospheres of air and nitrogen at room temperature. The wear scars and the wear debris were analyzed by X-ray photoelectron spectroscopy. The presence of air reduced wear but increased friction, while DBDS reduced friction but had little effect on wear except that the wear increased somewhat when DBDS was used in air. Wear scar analysis indicated that oxygen and sulfur competed chemically for the surface, with the oxide predominating Low wear was associated with a thick oxide layer and low friction with a thin predominantly sulfide layer. Analysis of the wear debris indicated the presence of a sulfate in the high wear case (hexadecane plus DBDS in air), and showed the presence of an organic sulfide in the low wear case (Hexadecane plus DBDS in nitrogen).

Author

A79-14798 \* # Adhesive bonding of ion beam textured metals and fluoropolymers. M. J. Mirtich and J. S. Sovey (NASA, Lewis Research Center, Cleveland, Ohio). American Vacuum Society, National Vacuum Symposium, 25th, San Francisco, Calif., Nov. 28-Dec. 1, 1978, Paper. 13 p. 12 refs.

An electron-bombardment argon ion source was used to ion-etch various metals and fluoropolymers. The metal and fluoropolymers were exposed to (0.5 to 1.0)-keV Ar ions at ion current densities of 0.2 to 1.5 mA/sq cm for various exposure times. The resulting surface texture is in the form of needles or spires whose vertical dimensions may range from tenths to hundreds of micrometers, depending on the selection of beam energy, ion current density, and etch time. The bonding of textured surfaces is accomplished by ion-beam texturing mating pieces of either metals or fluoropolymers and applying a bonding agent which wets in and around the microscopic conelike structures. After bonding, both tensile and shear strength measurements were made on the samples. Also tested, for comparison's sake, were untextured and chemically etched fluoropolymers. The results of these measurements are presented in this paper. (Author)

A79-14951 \* # Application of ion chromatography to the study of hydrolysis of some halogenated hydrocarbons at ambient temperatures. D. A. Otterson (NASA, Lewis Research Center, Cleveland, Ohio). Dionex Corp., Symposium on Ion Chromatography, Sunnyvale, Calif., June 21, 1978, Paper. 23 p. 10 refs.

A79-27232 \* Coatings for wear and lubrication. T. Spalvins (NASA, Lewis Research Center, Cleveland, Ohio). (International Conference on Metallurgical Coatings, San Francisco, Calif., Apr. 3-7, 1978.) Thin Solid Films, vol. 53, 1978, p. 285-300. 43 refs.

In this paper we review the recent advances in the tribological uses of R.F.-sputtered and ion-plated films of solid film lubricants (laminar solids, soft metals, organic polymers) and wear-resistant refractory compounds (carbides, nitrides, silicides). The couttering and ion-plating potentials and the corresponding coatings for ned are evaluated relative to the friction coefficient, wear endurance lits and mechanical properties. The tribological and mechanical properties of each kind of film are discussed in terms of film adherence, coherence, density, grain size, morphology, internal stresses and thickness and substrate conditions such as temperature, topography, chemistry and d.c. biasing. The ion-plated metallic films in addition to improved tribological properties also have better mechanical properties such as tensile strength and fatigue life. (Author)

A79-49536 \* # Electrochemical fluorination of trichloroethylene and N, N-dimethyltrifluoroacetamide. L.-C. Hsu (NASA, Lewis Research Center, Cleveland, Ohio), Electrochemical Society, Meeting, 155th, Boston, Mass., May 6-11, 1979, Paper, 12 p. 6 refs.

The paper presents the results of experiments concerning the fluorination of trichloroethylene and N, N-dimethyltrifluoroacetamide carried out on a laboratory scale in an advanced 'Simons' type electrochemical apparatus which could be operated automatically from ambient to 50 psi pressure. It is shown that a variety of fluorine-substituted products are formed, depending upon electrolysis conditions and concentrations of reactant relative to the NaF, KF, HF electrolyte. A new reaction mechanism of electrochemical fluorination of trichloroethylene is proposed. Finally, the solvency to-fluorine content relationship of fluorinated N, N-dimethyltrifluoroacetamide is described.

A79-32924 \* The catalysis of nucleotide polymerization by computed of divalent lead. H. L. Sleeper and L. E. Orgel (Salk Institute for Biological Studies, San Diego, Calif.). *Journal of Molecular Evolution*, vol. 12, Apr. 12, 1979, p. 357-364. 11 refs. Grant No. NGR-05-067-001.

The nonenzymatic, nontemplate catalysis of nucleotide polymerization by Pb(2+) ions, a possible prebiotic catalyst, is reported. Adenosine and uridine phosphoimidazoles were reacted in buffered solutions of lead salts and products were analyzed by means of paper chromatography and electrophoresis. In the presence of Pb(2+) ion at pH 8.0 and 7.0 the reaction is found to progress rapidly with excellent yields of oligomers, with optimal yields observed at pH 8.0. Little temperature dependence in the range 0 to 30 C is observed, however hydrolysis of the reaction products is minimal when the reaction is carried out at 0 C. Results show that the yield of oligomers is insensitive to mixing or the source of lead ions, indicating that naturally occurring minerals or precipitates could be a source of Pb(2+) ions under prebiotic conditions. (Author)

### **24** COMPOSITE MATERIALS

Includes laminates

N79-15157°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DYNAMIC MECHANICAL ANALYSIS OF FIBER REIN-FORCED COMPOSITES

Katherine E. Reed 1979 20 p refs. Presented at 34th Ann. Conf. of Reinforced Plastics/Composites of the Inst. of the Soc. of the Plastics Industry, Inc., New Orleans, La., 29 Jan. - 2 Feb. 1979

(NASA-TM-79033: E-9831) Avail NTIS HC A02/MF A01 CSCL 11D

Dynamic mechanical and thermal properties were determined for unidirectional epoxy/glass composites at various fiber orientation angles. Resonant frequency and relative logarithmic decrement were measured as functions of temperature. In low angle and longitudinal specimens a transition was observed above the resin glass transition temperature which was manifested mechanically as an additional damping peak and thermally as a change in the coefficient of thermal expansion. The new transition was attributed to a heterogeneous resin matrix induced by the fiber. The temperature span of the glass-rubber relaxation was found to broaden with decreasing orientation angle, reflecting the growth of fiber contribution and exhibiting behavior similar to that of Young's modulus. The change in resonant frequency through the glass transition was greatest for samples of intermediate fiber angle, demonstrating behavior similar to that of the longitudinal shear modulus.

N79-16075\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EFFECTS OF GRAPHITE FIBER STABILITY ON THE PROPERTIES OF PMR POLYIMIDE COMPOSITES

Peter Delvigs, William B. Alston (Army Aviation Res. and Develop Command, Cleveland, Ohio), and Raymond D. Vannucci. 1979. 18 p. refs. To be presented at the 24th Natl. SAMPE. Symp., San Francisco, 8-10 May 1979.

(NASA-TM-79062 E 9877 AVRADCOM-TR-78-62) Avail NTIS HC A02/MF A01 CSCL 11D

The effect of the stability of graphite fibers on composite properties after exposure in air at 600 F was investigated. Composites were fabricated from PMR-15 and PMR-2 monomer solutions, using HTS-2 and Celion 6000 graphite fibers as the reinforcement. The effect of long-term exposure in air at 600 F on composite weight loss and mechanical properties was determined. These composites exhibited a significantly increased lifetime at that temperature compared to composites fabricated from HTS fiber sold prior to 1975. The effect of the PMR-15 and PMR-II resin compositions on long-term composite performance at 600 F is also discussed.

N79-16076\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SOME PROPERTIES OF AN ADVANCED BORON FIBER
Donald R Behrendt 1979 11 p refs Presented at the Meeting
of the Am. Ceramic Soc. Merritt Island. Fla., 22:24 Jan. 1979
(NASA-TM 79065, E-9881) Avail NTIS. HC A02/MF A01
CSCL 11D

An advanced coreless boron fiber exhibits tensile strengths which are more than twice that of the normal CVD B/W fibers. The coreless fiber is made by the chemical removal of the tungsten boride core exposed by splitting the as-grown fiber. The easily splittable fiber is made by the chemical vapor deposition of boron on a larger than usual tungsten substrate. It is expected that the ease of splitting is related to residual stresses in these fibers. Measurements of the axial residual stresses in both the normal and the splittable fibers are presented and the results compared. Differences in these stresses are discussed in connection with the ease of splitting in the splittable fibers.

ARH

N79-16077\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HIGH TEMPERATURE DYNAMIC MODULUS AND DAMPING OF ALUMINUM AND TITANIUM MATRIX COMPOSITES

J. A. DiCarlo and J. E. Maisel (Cleveland State Univ.) 1979 37 p. refs. Presented at the Symp. on Advanced Fibers and Composites for Appl. at Elevated Temp., New Orleans, 18-22. Feb. 1979. sponsored by the Met. Soc. of AIME.

(NASA-TM-79080; E-9901) Avail: NTIS HC A03/MF A01 CSCL 11D

Dynamic modulus and damping capacity property data were measured from 20 to over 500 C for unidirectional B/AI (1100). B/AI (6061), B/SiC/AI (6061), AI2O3/AI, SiC/Ti-6AI-4V, and SiC/Ti composites. The measurements were made under vacuum by the forced vibration of composite bars at free-free flexural resonance near 2000 Hz and at amplitudes below 0.000001. Whereas little variation was observed in the dynamic moduli of specimens with approximately the same fiber content (50 percent), the damping of B/Al composites was found at all temperatures to be significantly greater than the damping of the Al2O3/Al and SiC/Ti composites. For those few situations where slight deviations from theory were observed, the dynamic data were examined for information concerning microstructural changes induced by composite fabrication and thermal treatment. The 270 C damping peak observed in B/AI (6061) composites after heat treatment above 460 C appears to be the result of a change in the 6061 aluminum alloy microstructure induced by interaction with the boron fibers. The growth characteristics of the damping peak suggest its possible value for monitoring fiber strength degration caused by excess thermal treatment during B/Al (6061) fabrication and use. SES

N79-16918\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

CHARACTERIZATION OF PMR POLYIMIDES: CORRELA-TION OF ESTER IMPURITIES WITH COMPOSITE PROPER-TIES

R W Lauver and R D Vannucci 1979 12 p refs To be presented at the 24th Natl SAMPE Symp, San Francisco, 8-10 May 1979

(NASA-TM-79068, E-9884) Avail NTIS HC A02/MF A01 CSCL 11D

The presumed relationship of chemical impurities to final composite properties was investigated for PMR-polyimide resin Ester/acid solutions of one monomer were aged at selected temperatures and chemical changes were monitored spectroscopically. At selected intervals, graphite fiber reinforced composite panels were fabricated. Changes in resin processing characteristics and composite properties were determined. The correlation of these data are discussed as are related characterization studies of PMR-polyimide resin.

A R H

N79-16919\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

PREDICTION OF PROPERTIES OF INTRAPLY HYBRID COMPOSITES

C C Chamis and J H Sinclair 1979 19 p refs Presented at the 34th Ann Conf of the Reinforced Plastics/Composite Inst. New Orleans, 29 Jan 1979 - 2 Feb 1979 (NASA-TM-79087, E-9911) Avail NTIS HC A02/MF A01 CSCL 11D

Equations based on the mixtures rule are presented for predicting the physical, thermal, hygral, and mechanical properties of unidirectional intraply hybrid composites (UIHC) from the corresponding properties of their constituent composites. Bounds were derived for uniaxial longitudinal strengths, tension, compression, and flexure of UIHC. The equations predict shear and flexural properties which agree with experimental data from UIHC. Use of these equations in a composites mechanics computer code predicted flexural moduli which agree with experimental data from various intraply hybrid anglepted laminates (IHAL). It is indicated briefly flow these equations can be used in conjunction with composite mechanics and structural analysis during the analysis/design process.

Author

N79-16920\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RESIN/FIBER THERMO-OXIDATIVE INTERACTIONS IN PMR POLYMIDE/GRAPHITE COMPOSITES

William B. Alston 1979 13 p refs To be presented at the 24th SAMPE Symp., San Francisco, 8-10 May, 1979 Prepared in part by Army Aviation Res. and Develop. Command, Cleveland, Ohio.

(NASA-TM-79093: AVRADCOM-TR-79-6; E-9917) Avail NTIS HC A02/MF A01 CSCL 11D

The amounts of resin weight loss and fiber weight loss in four PMR-polyimide graphite fiber composites were calculated from the composite weight losses and the fiber/resin ratios of the composites after long term thermo-oxidative aging in 600 F air. The accelerating effect of graphite fiber on resin weight loss, compared to neat resin weight loss, indicated the presence of a deleterious resin/fiber thermo-oxidative interaction, presumably due to fiber impurities. Similarly, the decelerating effect of the protective matrix resin on fiber weight loss, compared to bare fiber weight loss, was also demonstrated. The amount of hydrazine-indigestible resin and the amount of loose surface graphite fiber that formed during 600 deg. F. exposure of the composites were quantitatively determined. The indigestible residual resin was also qualitatively studied by scanning electron microscopy.

Author

N79-16921\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STABILITY OF PMR-POLYIMIDE MONOMER SOLUTIONS Richard W Lauver, William B. Alston, and Raymond D. Vannucci 1979 15 p. refs. Prepared in part by Army Aviation Res. and Develop Command, Cleveland

(NASA-TM-79063, E-9878, AVRADCOM-TR-78-63) Avail NTIS HC A02/MF A01 CSCL 11D

The stability of alcohol solutions of norborneyl capped PMR-polyimide resins was monitored during storage at ambient and subambient temperatures. Chemical changes during storage were determined spectroscopically using nuclear magnetic resonance Resin processability and cured resin quality were determined by fabrication of unidirectional, graphite fiber composites using aged solutions and testing of selected composite properties PMR-15 solutions exhibit nominally two weeks of useful life and PMR-2 solutions exhibit nominally two days of useful life at ambient conditions. The limiting factor is precipitation of imide reaction produces from the monomer solutions. Both solutions exhibit substantially longer useful lifetimes in subambient storage PMR-15 shows no precipitation after several months storage at subambient temperatures PMR-2 solutions do exhibit precipitates after extended subambient storage, however, the precipitates formed under these conditions can be redissolved. The chemical implications of these observations are discussed.

LS

N79-17916\* National Aeronautics and Space Administration.
Lewis Research Center Cloveland Ohio.

METHOD OF MAKING BEARING MATERIALS Patent
Harold E. Sliney, inventor (to NASA). Issued 23 Jan. 1979
5 p. Filed 13 Dec. 1977. Division of U.S. Patent Appl. SN-764245.

5 p Filed 13 Dec 1977 Division of US Patent Appl SN-764245, filed 31 Jan 1977, which is a division of abandoned US Patent Appl SN-616528, filed 25 Sep 1975, which is a division of US Patent Appl SN-513611, filed 10 Oct. 1974, US-Patent-3, 953 343

(NASA-Case-LEW-11930-4, US-Patent-4.136,211,

US-Patent-Appl-SN-860406, US-Patent-Class-427-34,

US-Patent-Class 252-12 2 US-Patent-Class-308-78,

US-Patent-Class-308-87R, US-Patent-Class-308-168, US-Patent-Class-308-171, US-Patent-Class-308-DIG.8,

US-Patent Class 308-DIG 9. US-Patent Class-427-292

US-Patent Class-427-327 US Patent Class-427-328.

US-Patent-Class-427-355, US-Patent-Class-427-376B.

US-Patent-Class-427-376C. US-Patent-3.953,343.

US-Patent Appl SN-764245, US-Patent Appl SN-616528

US-Patent-Appl-SN 513611) Avail US Patent and Trademark Office CSCL 11D

A method is described for making a composite material which provides low friction surfaces for materials in rolling or sliding

contact. The composite material which is self-lubricating and oxidation resistant up to and in excess of about 930 C is comprised of a metal component which lends strength and elasticity to the structure and a fluorine salt component which provides oxidation protection to the metal but may also enhance the lubrication qualities of the composite.

Official Gazette of the U.S. Patent and Trademark Office

N79-12150\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STATUS REVIEW OF PMR POLYIMIDES

Tito T. Serafini 1978 8 p refs Proposed for presentation at the Symp. on Resins for Aerospace at the Am. Chem. Soc./Chem. Soc. of Japan Chem. Congr., Honolulu, 1-6 Apr. 1979 (NASA-TM-79039; E-9841) Avail: NTIS HC A02/MF A01 CSCL 11D

The current status of first and second generation PMR pulyimides are reviewed. Synthesis, processing, and applications were considered, using prepreg materials based on processable, high temperature resistant polyimides.

N79-12153\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EVALUATION OF MANUFACTURING PROCESSES FOR BORON/ALUMINUM COMPOSITES CONTAINING 0.2-mm-DIAMETER BORON FIBERS

Thomas J. Moore and Paul E. Moorhead Nov. 1978 55 p (NASA-TM-79008; E-9792) Avail: NTIS HC A04/MF A01 CSCL 11D

The effects of starting materials and fabrication techniques on the properties and cost of producing boron/aluminum (B/Al) composite panels containing 0.2-mm-diameter boron fibers are evaluated. The boron fibers were obtained from a single supplier. Five kinds of B/Al tape were used to produce 105. 8-ply panels. Consolidation was accomplished by hot pressing in air or in vacuum. Nondestructive and destructive tests included room-temperature tensile tests. On the basis of an evaluation of the test results and relative cost estimates, two kinds of tape were selected for use, fugitive binder tape and dry woven tape.

N79-12154\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

FRACTURE MODES IN OFF-AXIS FIBER COMPOSITES

J H Sinclair and C. C Chamis 1978 25 p refs Proposed for presentation at the 34th Ann Conf. of the SPI Reinforced Plastics/Composites Inst., New Orleans, 29 Jan - 2 Feb 1979 (NASA-TM-79036, E-9836) Avail NTIS HC A02/MF A01 CSCL 11D

Criteria were developed for identifying, characterizing, and quantifying fracture modes in high-modulus graphite-fiber/resin unidirectional composites subjected to off-axis tensile loading Procedures are described which use sensitivity analyses and off-axis data to determine the uniaxial strength of fiber composites. It was found that off-axis composites fail by three fracture modes which produce unique fracture surface characteristics. The stress that dominates each fracture mode and the load angle range of its dominance can be identified. Linear composite mechanics is adequate to describe quantitatively the mechanical behavior of off-axis composites. The uniaxial strengths predicted from off-axis data are comparable to these measured in uniaxial tests. G.Y.

N79-20186° Mational Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

MECHANISMS OF BORON FIBER STRENGTHENING BY THERMAL TREATMENT

J A. DiCarlo 1979 27 p refs Presented at 3d Ann. Conf. on Composites and Advanced Mater, Merritt Island, Fla., 21-24 Jan 1979; Sponsored in part by the Am. Ceram. Soc. INASA-TM-79077, E-9894) Avail NTIS HC A03/MF A01 CSCL 11D

The fracture strain for boron on tungsten fibers was studied for improvement by heat treatment under vacuum or argon

environments. The mechanical basis for this improvement is thermally-induced axial contraction of the entire fiber, whereby strength-controlling core flaws are compressed and fiber fracture strain increased by the value of the confraction strain. By highly sensitive measurements of fiber density and volume, the physical mechanism responsible for contraction under both environments was identified as boron atom diffusion out of the fiber sheath. The fiber contracts because the average volume of the resulting microvoid was determined to be only 0.26 plus or minus 0.09 the average atomic volume of the removed atom. The basic and practical implications of these results are discussed with particular emphasis on the theory, use, and limitations of heat-induced contraction as a simple cost-effective secondary processing method. Author

N79-20187°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TUMGSTEN FIBER REINFORCED FOCALY: A FIRST GENERATION COMPOSITE TURBINE BLADE MATERIAL D. W. Petrasek, E. A. Winsa, L. J. Westfall, and R. A. Signorelli 1979 27 p refs Presented at the 108th Ann. meeting of the Am. Inst. of Mining. Met. and Petroleum Engr., New Orleans, 18-22 Feb. 1979

(NASA-TM-79094; E-9918) Avail: NTIS HC A03/MF A01 CSCL 11D

Tungsten-fiber/FeCrAlY (W/FeCrAlY) was identified as a promising aircraft engine, first generation, turbine blade composite material. Based on available data, W/FeCrAlY should have the stress-rupture, creep, tensile, fatigue, and impact strengths required for turbine blades operating from 1250 to 1370 K. It should also have adequate oxidation, hot corrosion, and thermal cycling damage resistance as well as high thermal conductivity Concepts for potentially low cost blade fabrication were developed. These concepts were used to design a first stage JT9D convection cooled turbine blade having a calculated 50 K use-temperature advantage over the directionally solidified superalloy blade. L.S.

N79-20188° National Aeronautics and Space Administration. Lewis Research Center Cleveland Ohio

FABRICATION AND TESTING OF NONGRAPHITIC SUPERHYBRID COMPOSITES

R. F. Lark, J. H. Sinclair, and C. C. Chamis 1979 17 p refs To be presented at the 24th Natl. SAMPE Symp., San Francisco, 8-10 May 1979

(NASA-TM-79102; E-9926) HC A02/MF A01 CSCL 11D

The fabrication feasibility and the mechanical properties of adhesively-bonded boron/aluminum, titanium, nongraphitic fiber/epoxy-resin superhybrid composite laminates were studied for potential aerospace applications. The major guiding force was the elimination of a potential graphite fiber release problem in the event of a fire. Results show that nongraphitic fibers, such as S-glass and Kevlar 49, can be substituted for the graphite fibers used in superhybrid composites. However, the nongraphic superhydrids have lower stiffness proparties than the graphitic superhybrids. In-plane and flexural moduli of the laminates studied can be predicted using linear laminate theory, while nonlinear laminate theory is required for strength predictions.

N79-22211\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

DEVELOPMENT AND FABRICATION OF HIGH STRENGTH ALLOY FIBERS FOR USE IN METAL-METAL MATRIX COMPOSITES

G. W. King (Westinghouse Electric Corp., Bloomfield, N. J.) and D W Petrasek 1979 15 p refs Presented at the 108th Ann. Meeting of the Am. inst. of Mining, Met. and Petroleum Engr. New Orleans, 18-22 Feb 1979

(NASA-TM-79115 E-9951) Avail NTIS HC A02/MF A01 CSCL 11D

Metal fiber reinforced superalloys are being considered for construction of critical components in turbine engines that operate at high temperature. The problems involved in fabricating refractory metal alloys into wire form in such a manner as to maximize their strength properties without developing excessive

structural defects are described. The fundamental principles underlying the development of such ailoy fibers are also briefly discussed. The progress made to date in developing tungsten, tantalum and columbium base alloys for fiber reinforcement is reported and future prospects for alloy fiber development considered Author

N79-28234\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMAL CONDUCTIVITY MEASUREMENTS OF TUN. STEN-FIBER-REINFORCED SUPERALLOY COMPOSITES USING A THERMAL-CONDUCTIVITY COMPARATOR

Leonard J. Westfall and Edward A. Winsa Jul. 1979

(NASA-TP-1445, E-9910) Avail NTIS HC A02/MF A01 CSCL 11D

The thermal conductivity (TC) of tungsten-fiber-reinforced superalloys was determined for two composite systems by using a thermal conductivity standard from the National Bureau of Standards and a comparator and technique developed for that purpose. The results were compared with TC data for the nickel-base alloy MAR-M200. The technique lends itself to applications involving thin specimens, such as thin-walled turbine blades. The TC's of the composite systems were considerably higher in both the longitudinal and transverse directions than that of the monolithic superallovs used as the matrices. Author

National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER AND LABORATORY SIMULATION OF INTER-ACTIONS BETWEEN SPACECRAFT SURFACES AND CHARGED-PARTICLE ENVIRONMENTS

N. John Stevens 1979 39 p refs Presented at 12th Fluio and Plasma Dyn. Conf., Williamsburg, Va., 24-26 Jul. 1979; sponsored by AIAA

(NASA-TM-79219, E-111) Avail: NTIS HC A03/MF A01 CSCL

Cases where the charged-particle environment acts on the spacecraft (e.g., spacecraft charging phenomena) and cases where a system on the spacecraft causes the interaction (e.g., high voltage space power systems) are considered. Both categories were studied in ground simulation facilities to understand the processes involved and to measure the pertinent parameters. Computer simulations are based on the NASA Charging Analyzer Program (NASCAP) code Analytical models are developed in this code and verified against the experimental data. Extrapolation from the small test samples to space conditions are made with this code. Typical results from laboratory and computer simulations are presented for both types of interactions. Extrapolations from these simulations to performance in space environments are ARH discussed

N79-29240°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HIGH CHAR IMIDE MODIFIED EPOXY MATRIX RESINS Tito T. Serafini, Peter Delvigs, and Raymond D. Vannucci. 1979. 12 p refs Proposed for presentation at 11th Natl. SAMPE Tech Conf. Boston, 13-15 Nov. 1979 (NASA-TM-79226, E-123) Avail NTIS HC A02/MF A01 CSCL

11D

The synthesis of a class of bis(imide-amine) curing agents for epoxy matrix resins is discussed. Glass transition temperatures and char yield data of an epoxy cured with various bislimideamines) are presented. The room temperature and 350 F. mechanical properties, and char yields of unidirectional graphite fibe laminates prepared with conventional epoxy and imidemodified epoxy resins are presented ARH

N79-30296\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

## FATIGUE BEHAVIOR OF SIC REINFORCED TITANIUM COMPOSITES

R. T. Bhatt and H. H. Grimes. 1979. 19 p. refs. Presented at Symp. on Fatigue of Fibrous Composite Mater. San Francisco. 22-23. May. 1979. sponsored by Arn. Soc. for Testing and Mater.

(NASA-TM-79223, E-118) Avail NTIS HC A02/MF A01 CSCL

The low cycle axial fatigue properties of 25 and 44 fiber volume percent SiC/Ti(6AI-4V) composites were measured at room temperature and at 650 deg C. The S-N curves for the composites showed no anticipated improvement over bulk matrix behavior at room temperature. Although axial and transverse tensile strength results suggest a degradation in SiC fiber strength during composite fabrication, it appears that the poor fatigue life of the composites was caused by a reduced fatigue resistance of the reinforced Ti(6AI-4V) matrix. The reduced matrix behavior was due, to the presence of flawed and fractuled fibers created near the specimen surfaces by preparation techniques and to the large lesidual tensile stresses that can exist in fiber reinforced matrices. The effects of fatigue testing at high temperature are discussed.

N79-30323\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

## RECENT DEVELOPMENTS IN PMR POLYIMIDES AT NASA LEWIS

T.T. Serafini. In NASA. Langley Res. Center. Graphite/Polyimide. Composites. Aug. 1979. p. 391-412. refs. (For primary document see. N79-30297, 21-24).

Avail NTIS HC A19/MF A01 CSCL 11D

The following areas of PMR polyimide research were reviewed (1) prepreg tack and drape, (2) cure temperature, (3) solution characterization, and (4) elevated temperature composite propertias. Recent hardware applications of PMR-15 by various fabricators were also reviewed.

 $\mbox{N79-31349}^{\bullet}\#$  National Aeronautics and Space Administration Lewis Research Center. Cleveland, Ohio

## EVALUATION OF SILICON CARBIDE FIBER/TITANIUM COMPOSITES

R W Jech and R A Signorelli Jul 1979 28 p. refs (NASA-TM 79232, E-134) Avail NTIS HC A03/MF A01 CSCL

Izod impact tensile, any modulus of elasticity were determined for silicon carbide liber/titanium composites to evaluate their potential usefulness as substitutes for titanium alloys or stainless steel in stiffness critical applications for aircraft turbine engines Variations in processing conditions and matrix ductility were examined to produce composites having good impact strength in both the as-fabricated condition and after air exposure at elevated temperature. The impact strengths of composites containing 36 volume percent silicon carbide (SiC) fiber in an unalloyed (A-40) titanium matrix were found to be equal to unreinforced titanium 6 aluminum 4 vanadium alloy, the tensile strengths of the composites were marginally better than tha unreinforced unalloyed (A.70) matrix at elevated temperature though not at room temperature. At room temperature the modulus of elasticity of the composites was 48 percent higher than titanium or its alloys and 40 percent higher than that of stainless steel Author

A79.15543 \* The effects of eccentricities on the fracture of off-axis fiber composites. C. C. Chamis and J. H. Sinclair (NASA, Lewis Research Center, Materials and Structures. Dis., Cleveland, Ohiol. In. Reinforced Plastics Composites Institute. Annual Conterence, 33rd, Washington, D.C., February 7.10, 1978, Propredings (A79.15526.04.24). New York, Succeey of the Plastics Industry. Inc., 1978, p. 22.A.1 to 22.A.6.5 refs.

Finite element analysis were performed to investigate theoretically the effects of in-plane and out of plane eccentricities, bending or twisting, and thickness conventionity on the axial stress and

strain variations across the width of off-axis specimens. The results are compared with measured data and are also used to access the effects of these eccentricities on the fracture stress of off-axis fiber composites. Guidelines for detecting and minimizing the presence of eccentricities are described.

(Author)

A79-15545 \* # Use of an ultrasonic-acoustic technique for nondestructive evaluation of fiber composite strength. A. Vary and K. J. Bowles (NASA, Lewis Research Center, Cleveland, Ohio). In: Reinforced Plastics/Composites Institute, Annual Conference, 33rd, Washington, D.C., February 7-10, 1978, Proceedings. (A79-15526 04-24) New York, Society of the Plastics Industry, Inc., 1978, p. 24-A 1 to 24-A 5. 5 refs.

This report describes the ultrasonic-acoustic technique used to measure a 'Stress Wave Factor'. In a prior study this factor was found effective in evaluating the interlaminar shear strength of fiberreinforced composites. Details of the method used to measure the stress wave factor are described. In addition, frequency spectra of the stress waves are analyzed in order to clarify the nature of the wave phenomena involved. The stress wave factor can be measured with simple contact probes requiring only one-side access to a part. This is beneficial in nondestructive evaluations because the waves can run parallel to fiber directions and thus measure material properties in directions assumed by actual loads. Moreover, the technique can be applied where conventional through transmission techniques are impractical or where more quantitative data are required. The stress wave factor was measured for a series of graphite/polyimide composite panels and results obtained are compared with through (Author) transmission immersion ultrasonic scans.

A79-20836 \* Titanium/beryllium laminates - Fabrication, mechanical properties, and potential aerospace applications. C. C. Chamis and R. F. Lark (NASA, Lewis Research Center, Cleveland, Ohio). In: Selective application of materials for products and energy. Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801-07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 611-632, 5 refs.

The paper describes an investigation to assess the fabricability, mechanical properties, and possible aerospace applications of adhesively-bonded titanium/beryllium Tiber laminates. The results of the investigation indicate that structural laminates can be male which have a modulus of elasticity comparable to steel, fracture strength comparable to the yield strength of titanium, density comparable to aluminum, impact resistance comparable to titanium, and little or no notch rensitivity. These laminates can have stiffness and weight advantages over other materials, including advanced fiber composites, in some aerospace applications where buckling resistance, vibration' frequencies, and weight considerations control the design.

(Author)

A79-24132 \* Effects of moisture profiles and laminate configuration on the hygro stress in advanced composites. C. C. Chamis. R. F. Lark, and J. H. Sinclair (NASA, Levels Research Center, Cleveland, Ohio). \*\* Materials synergisms. Proceedings of the Tenth National Technical Conference, Kramesha Lake, N.Y. October 17-19, 1978. (A79-24076-08-31) Azusa, Calif. Society for tt.: Ad vancement of Material and Process Engineering, 1978, p. 584-700.

A theoretical investigation was performed using a recently developed integrated theory for predicting the hygrothermomechanical response to investigate the effects of three different moisture profiles on the ply hygro stresses in anglephed laminates. The moisture profiles were linear, parabolic and hyperbolic varying from 1 percent at the exposed ply to "0" percent in the protected ply. The anglephed laminates were of two generic configurations. The results obtained are summarized graphically to illustrate the effects of both moisture profile and laminate configuration. (Author)

A79-26132 \* # High temperature dynamic modulus and damping of aluminum and titanium matrix composites. J. A. DiCarlo (NASA, Lewis Research Center, Cleveland, Ohio) and J. E. Maisel (Cleveland State University, Cleveland, Ohio). Metallurgical Society of AIME, Symposium on Advanced Fibers and Composites for Application at Elevated Temperatures, New Orleans, La., Feb. 18-22, 1979, Paper. 36 p. 31 refs.

Dynamic modulus and damping capacity property data were measured from 20 to over 500 C for unidirectional B/AI (1100), B/AI (6061), S/SiC/AI (6061), AI2O3/AI, SiC/Ti-6AI-4V, and SiC/Ti composites. The measurements were made under vacuum by the forced vibration of composite bars at free-free flexural resonance near 2000 Hz and at strain application below 0.000001. The damping of B/AI composites was found at all temperatures to be significantly greater than the damping of the AI2O3/AI and SiC/Ti composites, with little variation observed in the dynamic moduli of specimens having almost the same fiber content. It is concluded that on the practical level, the finding of a damping-strength correlation supports the use of composite damping measurements for the nondestructive evaluation of boron fiber strength in as-fabricated and heat-treated B/AI (6061) composites.

A79-30396 \* # Mechanisms of boron fiber strengthening by thermal treatment. J. A. DiCarlo (NASA, Lewis Research Center, Cleveland, Ohio). American Ceramic Society, Annual Conference in Composites and Advanced Materials, 3rd, Merritt Island, Fla., Jan. 21-24, 1979, Paper, 25 p. 19 refs.

The fracture strain for boron on tungsten fibers can be improved by heat treatment under vacuum or argon environments. The mechanical basis for this improvement is thermally-induced axial contraction of the entire fiber, whereby strength-controlling core flaws are compressed and fiber fracture strain increased by the value of the contraction strain. By highly sensitive measurements of fiber density and volume, the physical mechanisms responsible for contraction under both environments was identified as boron atom diffusion out of the fiber sheath. The fiber contracts because the average volume of the resulting microvoid was determined to be only 0.26 + or - 0.09 the average atomic volume of the removed atom. The basic and practical implications of these results are discussed with particular emphasis on the theory, use, and limitations of he t-induced contraction as a simple cost-effective secondary processing method. (Author)

A79-30397 \* " Tungs\*en fiber reinforced FeCrAlY - A first generation composite turbine blade material, D. W. Petrasek, E. A. Winsa, L. J. Westfall, and R. A. Signorelli (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Mining, Metallurgical and Petroleum Engineers, Annual Meeting, 108th, New Orleans, La., Feb. 18-22, 1979, Paper, 27 p. 20 refs.

General and composite turbine blade material requirements are examined to identify a specific tungsten fiber reinforced superalloy (TERS) having, in addition to strength, the desired combination of other material propertie, needed in turbine blades. Experimental data indicated that a thill attend tungsten fiber reinforced FeCrAlY matrix composite should have the stress-rupture, creep, tensile, fatigue, and impact strengths required for turbine blades operating from 1250 to 1370 K. Fabrication and design concepts are developed to demonstrate the feasibility of fabricating a hollow TERS turbine blade at reasonable cost.

A.A.

A79-30399 \* « Status review of PMR polyimides. T. T. Serafini (NASA, Lewis Research Center, Cleveland, Ohio). American Chemical Society and Chemical Society of Japan, Symposium on Resins for Aerospace, Honoldiu. Hawaii, Apr. 16, 1979, Paper. 6 p. 14 lets.

In the NASA developed PMR (polymerization of monomer reactants), the reinforcing fibers are impregnated with a solution containing a mixture of monomers dissolved in a low boiling point alkyl alcohol solvent, with the monomers reacting in situ at elevated

temperatures to form a thermo-oxidatively stable polyimide matrix. The current status of first and second generation PMR polyimides is reviewed, considering synthesis and properties, processing, and applications. It is concluded that the PMR approach offers various significant advantages, especially superior high temperature properties and processing versatility, to fabricators and users of polyimide/fiber composites.

A.A.

A79-31033 \* # Mechanics of intraply hybrid composites - Properties, analysis and design. C. C. Chamis and J. H. Sinclair (NASA, Lewis Research Center, Materials and Structures Div., Cleveland, Ohio). In: Reinforcing the future; Proceedings of the Thirty-fourth Annual Conference, New Orleans, La., January 30-February 2, 1979, (A79-31026 12-24) New York, Society of the Plastics Industry, Inc., 1979, p. 20-E 1 to 20-E 8, 6 refs.

A mechanics theory is developed for predicting the physical thermal, hygral and mechanical properties (including various strengths) of unidirectional intraply fixed composites (UIHC) based on unidirectional properties of the constituent composites. Procedures are described which can use this theory in conjunction with composite mechanics computer codes and general purpose structural analysis finite element programs for the analysis/design of structural components made from intraply hybrid angleptied lam nates (IHAL). Comparisons with limited data show that this theory predicts mechanical properties of UIHC and flexural stiffnesses of IHAL which are in good agreement with experimental data. The theory developed herein makes it possible to design and optimize structural components from IHAL based on a large class of available constituent fibers.

(Author)

A79-31035.\* Fracture modes in off-axis fiber composites, J. H. Sinclair and C. C. Chamis (NASA, Lewis Research Center, Composites and Structures Branch, Cleveland, Ohio). In: Reinforcing the future: Proceedings of the Thirty-fourth Annual Conference, New Orleans, La., January 30-February 2, 1979. (A79-31026 12-24) New York, Society of the Plastics Industry, Inc., 1979, p. 22-A 1 to 22-A 11.8 refs.

Criteria have been developed for identifying, characterizing, and quantifying fracture modes in high-modulus graphite-fiber/resin unidirectional composites subjected to off-axis tensile loading. Procedures are described which use sensitivity analyses and off-axis data to determine the uniaxial strength of fiber composites. It was found that off-axis composites fail by three fracture modes which produce unique fracture surface characteristics. The stress that dominates each fracture mode and the load angle range of its dominance can be identified. Linear composite mechanics is adequate to describe quantitatively the mechanical behavior of off-axis composites. The uniaxial strengths predicted from off-axis data are comparable to those measured in uniaxial tests. (Author)

A79-31040 \* " Dynamic mechanical analysis of fiber reinforced composites. K. E. Reed (NAS \( \), Lewis Research Center, Materials and Structures Div., Cleveland, Ohio). In: Reinforcing the future: Proceedings of the Thirty-fourth Annual Conference, New Orleans, La., January 30-February 2, 1979. (A79-31026-12-24) New York, Society of the Plastics Industry, Inc., 1979, p. 22-G 1 to 22-G 5, 12 refs.

Dynamic mechanical and thermal properties were determined for un idirectional epoxy/glass composites at various fiber orientation angles. Resonant frequency and relative logarithmic decrement were measured as functions of temperature. In low angle and longitudinal specimens a transition was observed above the resin glass transition temperature which was manifested mechanically as an additional damping peak and thermally as a change in the coefficient of thermal expansion. The new transition was attributed to a heterogeneous resin matrix induced by the fiber. The temperature span of the glass-rubber relaxation was found to broaden with decreasing orientation angle, reflecting the growth of fiber contribution and exhibiting behavior similar to that of Young's modulus. The change in resonant frequency through the glass transition was greatest for

ting behavior similar (Author)

Characterization of PMR polyimides - Correlation of ester impurities with computate properties. R. W. Lauver and F. D. Vannucci (NASA, Lewis Research Center, Cleveland, Ohic). In: The enignm of the eighties: Environment, economics, energy; Proceedings of the Twenty-fourth National Symposium and Exhibition, Sen Francisco, Calif., Muy 8-10, 1979. Book 1. (A79-43278 18-23) Azusa, Calif., Society for the Advancement of Material and Process Enginuering, 1979, p. 522-532. 6 refs.

The presumed relationship of chemical impurities to final composite purperties is the rationale for most chemical characterization studies. This study examines this relationship for PMF-polyimide resin. Ester/acid solutions of one monomer were aged at selected temperatures and chemical changes were monitored spectroscopically. At selected intervals, graphite fiber reinforced composite panels were fabricated. Changes in resin processing characteristics and composite properties were determined. The correlation of these data are discussed as are related characterization studies of PMR-polyimide resin.

(Author)

A79-43239 \* Fabrication and testing of non-graphitic superhybrid composites. R. F., Lark, J. H., Sinctair, and C. C. Chamis (NASA, Lewis Research Center, Cleveland, Ohio). In: The enigma of the eighties: Environment, economics, energy: Proceedings of the Twenty-fourth National Symposium and Exhibition, San Francisco, Calif., May 8-10, 1979. Book 1. (A79-43228 18-23) Azusa, Calit., Society for the Advancement of Material and Process Engineering, 1979, p. 776-790. 6 refs.

A study was conducted to determine the fabrication feasibility and the mechanical properties of adhasively-bonded boron aluminum/titanium and nun-graphitic fiber/epoxy resin superhybrid (NGSE) composite laminates for potential aerospace applications. The major driver for this study was the elimination of a potential graphite fiber release problem in the event of a fire. The results of the study show that non-graphitic fibers, such as S-glass and Kevlar 49, now be substituted for the graphite fibers used in superhybrid (SH) composites for Lome applications. As is to be expected, however, the non-graphitic superhybrids have lower stiffness properties than the graphitic superhybrids have lower stiffness properties than the graphitic superhybrids, in-plane and flexural moduli of the laminates studied in this program can be practiced reasonably well using linear laminate theory while nonlinear laminate theory is required for strength predictions.

(Author)

A79-43309 \* Effects of graphite fiber stability on the properties of PMR polyimide composites. P. Delvigs, W. B. Alston, and R. D. Vannucci (NASA, Lewis Research Center: U.S. Army, Propulsion: Laboratory, Cleveland, Ohio). In The enigma of the eighties: Environment, economics, energy Proceedings of the Twenty-fourth National Symposium and Exh. Ition, San Francisco, Calif., May 8-10, 1979. Book 2. (A79-4%2 % 18-23) Azusa, Calif., Society for the Advancement of Material in Process Engineering, 1979, p. 1053-1068. 6 refs.

Studies were performed to investigate the efficient of the stability of graphite fibers on composite properties after exposure in air at 600 Fi. Composites were fabilitied from PMR-15 and PMR-11 monomer industries, using HTS-2 and Celion 6000 graphite fibers as the reinforcement. The effect of long-term exposure in air at 600 Fion composite weight loss and mechanical properties was determined. These composites exhibited a significantly increased lifetime at 600 Ficompared to composites fabricated from HTS fiber soil prior to 1975. The effect of the PMR-15 and PMR-II resin compositions on long term composite performance at 600 Fis also discussed.

(Author)

A79-49536 \* # Electrochemical fluorination of trichlorothylene and N, N-dimethyltrifluoroacetamide. L.-C. Hsu (NASA, Lewis Research Center, Cleveland, Ohio). Electrochemical Society, Meeting, 155th, Boston, Mass., May 6-11, 1979, Paper. 12 p. 6 refs.

The paper presents the results of experiments concerning the fluorination of trichloroethylene and N, N-dimethyltrifluoro-acetamide carried out on a laboratory scale in an advanced 'Simons' type electrochemical apparatus which could be operated automatically from ambient to 50 psi pressure. It is shown that a variety of fluorine-substituted products are formed, depending upon electrolysis conditions and concentrations of reestant relative to the NaF, KF, HF electrolyte. A new reaction mechanism of electrochemical fluorination of trichloroethylene is proposed. Finally, the solyancy-to-fluorine content relationship of fluorinated N, N-dimethyltrifluoroacetamide is described.

A79-53720 \* # Composites emerging for aeropropulsion applications. G. M. Ault and J. C. Freche (NASA, Lewis Research Center, Cleveland, Ohio). Astronautics and Aeronautics, vol. 17, Oct. 1979, p. 48-59, 80, 81, 47 refs.

The paper deals with applying composites to the cold- and hot-section components of aircraft turbine engines and analyzing composite structures. The primary experience to date has been with graphite-epoxy materials. The emerging new composites based on fabricable polyimides will find application in components that can operate at temperatures higher than the 350 F allowed by the epoxic. Further major benefits would result if the fiber-reinforced roft, mer composites could be used for key rotating components, such as the fans of large high-bypass-ratio engines. For the very critical hot turbine components, fiber-reinforced superalloys for turbine blades are considered.

N79-16924\* Nevada Engineering and Technology Corp., Long Beach, Calif

ELEVATED TEMPERATURE PROPERTIES OF BORON/ ALUMINUM COMPOSITES Final Report, 26 Jan. 1976 26 Jan. 1977

Pamela G Sullivan Nov 1978 116 p refs (Contract NAS3-20079)

(NASA-CR-159445) Avail NTIS HC A06/MF A01 CSCL

N79-26120\* # Boeing Aerospace Co. Seattle. Wash
EVALUATION OF FLAWED COMPOSITE STRUCTURAL
COMPONENTS UNDER STATIC AND CYCLIC LOADING
T. R. Porter Feb. 1979 255 p. refs

(Con'ract NAS3-19709)

(NASA-CR-135403) Avail NTIS HC A12/MF A01 CSCL

The effects of initial defects on the fatigue and fracture response of graphite-epoxy composite laminates are presented. The structural laminates investigated were a typical angle ply laminate, a polar/hop wound pressure vessel laminate, and a typical engine fan blade laminate. Defects investigated were full and half penetration circular holes, full and half penetration sitis, and countersink holes. The effects of the defect size and type on the static fracture strength, fatigue performance, and resicual static strength are shown as well as the results of loadings on

damage propagation in composite laminates. The data obtained were used to define proof test levels as a qualification procedure in composite structure subjected to cyclic loading.

N79-3 3294\* Lehigh Univ., Bethlehem, Pa. Inst. of Fracture and Solid Mechanics

OFF-AXIS IMPACT OF UNIDIRECTIONAL COMPOSITES WITH CRACKS: DYNAMIC STRESS INTENSIFICATION Interim Report

G. C. Sih and E. P. Chen Jan. 1979 65 p refs (Grent NsG-3179)

NA:3A-CR-159537

HC A04/MF A01 CSCL 11D

IFSM-79-95)

NTIS

The dynamic response of unidirectional composites under off axis (angle loading) impact is analyzed by assuming that the composite contains an initial flaw in the matrix material. The analytical method utilizes Fourier transform for the space variable and Laplace transform for the time variable. The off axis impact is separated into two parts, one being symmetric and the other skew-symmetric with reference to the crack plane. Transient boundary conditions of normal and shear tractions are applied to a crack embedded in the matrix of the unidirectional composite. The two boundary conditions are solved independently and the results superimposed. Mathematically, these conditions reduce the problem to a system of dual integral equations which are solved in the Laplace transform plane for the transformation of the dynamic stress intensity factor. The time inversion is carried out numerically for various combinations of the material properties of the composite and the results are displayed graphically.

N79-30295\*# General Electric Co. Cincinnati. Ohio. METAL SPAR/SUPERHYBRID SHELL COMPOSITE FAN **BLADES** Final Report

C T Salemme and G C Murphy Aug 1979 135 p (Contract NAS3-20402)

(NASA-CR-159594) Avail NTIS HC A07/MF A01 CSCL 11D

The use of superhybrid materials in the nanufacture and testing of large fan blades is analyzed. The FOD resistance of large metal spar/superhybrid fan blader is investigated. The technical effort reported was comprised of (1) preliminary blade design. (2) detailed analysis of two selected superhybrid blade designs. (3) manufacture of two process evaluation blades and destructive evaluation, and (4) manufacture and whirligig testing of AWH six prototype superhybrid blades

N79-31348\*# General Electric Co. Cincinnati. Ohio. Aircraft Engine Group

CONTAINMENT OF COMPOSITE FAN Final Report

C L Stotler and A P Coppa Jul 1979 144 p ref (Contract NAS3-20118) R79AEG1971 Avail NASA CR 159544

HC A07/MF A01 CSCL 11D

A lightweight containment was developed for turbofan engine fan blades. Subscale ballistic-type tests were first run on a number of concepts. The most promising configuration was selected and further evaluated by larger scale tests in a rotating test rig Weight savings made possible by the use of this new containment system were determined and extrapolated to a CF6-size engine An analytical technique was also developed to predict the released blades motion when involved in the blade/casing interaction process Initial checkout of this procedure was accomplished using several of the tests run during the program

N79-31350°# Celanese Research Co. Summit NJ ULTRAFINE POLYBENZIMIDAZOLE (PBI) FIBERS Final Report, Jun. 1976 - Jun. 1979

E.C. Chenevey Jun 1979 119 p refs Contract NAS3 20040)

INASA CR 1596441 Avail NTIS HC A06 MF A01 CSCL 11D Mats were made from ultrafine polybenzimidazole (PBI) fibers to provide an alternate to the use of asbestos as separators in fuel cells and alkaline batteries. To minimize distortion during mat drying, a process to provide a dry fibrid was develope 1. Two fibrid types were developed one coarse, making mats for battery separators; the other fine, making low permeability matrices for fuel cells. Eventually, it was demonstrated that suitable mat fabrication techniques yielded fuel cell separators from the coarser alkaline battery fibrids. The stability of PBI mats to 45% KOH at 123 C can be increased by heat treatment at high temperatures. Weight loss data to 1000 hours exposure show the alkali resistance of the mats to be superior to that of

N79-33258\* United Technologies Research Center, East DEVELOPMENT OF SIAION MATERIALS Final Report, Jun. 1576 - Sep. 1979 G K Layden Sep 1979 145 p refs (Contract NAS3-19712) (NASA-CR-159675. R79-912997-39) NTIS Avail HC AC7/MF AO1 CSCL 11D

Cold pressing and sintering techniques were used to produce ceramic test specimens in which the major phase was either Si3N4 or a solid solution having the beta Si3N4 structure Additional components were incorporated to promote liquid phase sintering Glass and/or crystalline phase were consequently retained in boundaries between Si3N4 grains which largely determined the physical properties of the bodies Systems investigated most extensively included R-Si-Al-O-N (R rare earth element) Zr-Si-Al-O-N, Y-Si-Be-O-N, and R1-R2-Si-O-N Room temperature and 1370 C modulus of ruptured, 1370 C creep, and oxidation behavior are discussed in terms of phase relationships in a parent guinery, and relavent oxide systems

Author

Increasing the FOD tolerance of composites. A79-20859 \* R. C. Novak (United Technologies Research Center, East Hartford, Conn.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 936-949, 7 refs. Contract No. NAS3-18941.

An experimental program was conducted for the purpose of increasing the foreign object damage tolerance of resin matrix composites in gas turbine engine fan blade applications. The superhybrid concept consisting of a resin matrix composite core surrounded by a sheath of boron/aluminum and titanium was found to be the most promising approach. (Author)

# 25 INORGANIC AND PHYSICAL CHEMISTRY

Includes chemical analysis, e.g., chromatography; combustion theory; electrochemistry; and photochemistry.

For related information see also 77 Thermodynamics and Statistical Physics.

N79-12180°# National Aeronautics and Space Administration. Lawis Research Center, Cleveland, Ohio.

CATALYST SURFACES FOR THE CMROMOUS/CHROMIC REDOX COUPLE Patent Application

Jose D. Giner (Giner, Inc., Waltham., Mass.) and Kathleen J. Cahill, inventors (to NASA) (Ginar, Inc., Waltham, Mass.) Filed 29 Nov. 1978. 16 p. Sponsored by NASA.

(NASA-Case-LEW-13148-1, US-Patent-Appl-SN 964754) Avail NTIS HC A02/MF A01 CSCL 07D

An electricity producing cell of the reduction oxidation (REDOX) type is described. The cell comprises a container divided into anode and cathode compartments respectively, by an ion permeable membrane. An anode fluid is directed through a compartment from a source while a cathode fluid is directed through a different compartment from a different source. These fluids are aqueous. HCI solutions each containing a different metallic chloride salt. In an exemplary cell the anode fluid contains chromium chloride while the cathode fluid contains iron chloride. Circulation of the anode and cathode fluids produces a difference of potential between inert, electrically conductive electrodes.

N79-14172\* 

Mational Aeronautics and Space Administration.

Lewis Research Center Cleveland Ohio

METHOD OF CROSS-LINKING POLYVINYL ALCOHOL AND OTHER WATER SOLUBLE RESINS Patent Application

D. W. Sheibley, W. H. Philipp, and L. C. Hsu, inventors (to NASA). Filed 20 Dec. 1978, 13 p.

(NASA-Case-LEW-13103-1; US-Patent-Appl-SN-971596) Avail NTIS HC A02/MF A01 CSCL 07D

A self-supporting sheet structure comprising a water soluble, non-cross-linked polymer, such as polyvinyl alcohol, is reported which is capable of being cross-linked by reaction with hydrogen atom radicals and hydroxyl molecule radicals in an aqueous solution having a pH of less than 8 and containing a dissolved salt in an amount sufficient to prevent dissolution of the non-cross-linked polymer. The aqueous solution is then irradiated with ionizing radiation to form hydrogen atom radicals and hydroxyl molecule radicals. The irradiation is continued for a time sufficient to produce a water-insoluble polymer sheet structure. The method has particular application in the production of battery separators and electrode envelopes for alkaline batteries.

N79-14173\*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

CROSS-LINKED POLYVINYL ALCOHOL AND METHOD OF MAKING SAME Patent Application

Li-Chen Hsu, Dean W. Heibley, and Warren H. Philipp, inventors (to NASA). Filed 20 Dec. 1978. 12 p.

(NASA-Case-LEW-13101-1, US-Patent-Appl-SN-971473) Avail NTIS HC A02/MF A01 CSCL 07D

A polyvinyl alcohol battery separator is described which has good tensile strength, good resistance to conditions prevailing in alkaline batteries, and an electrical resistivity of less than 1 ohm/sq cm. The product is made by admixing polyvinyl alcohol, preferably in the form of a readily available aqueous solution, and a polyaldehyde-polysaccharide such as inexpensive, readily available polydialdehyde starch. The admixture is formed into a sheet by casting an aqueous admixture of the resin and the cross-linking agent. The dried sheet or film is cut to size if desired and may be assembled into bag form for use in a battery Cross-linking is effected by contacting the film, with a conventional aqueous acid catalyst solution. In an amount sufficient to prevent dissolution of the polymer in the aqueous acid solution. NASA

N79-14174\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IN-SITU CROSS-LINKING OF POLYVINYL ALCOHOL Patent Application .

W. H. Philipp, L. C. Hsu, and D. W. Sheibley, inventors (to NASA). Filed 20 Dec. 1978, 13 p.

(NASA-Case-LEW-13135-1; US-Patent-Appl-SN-971475) Avail: NTIS HC A02/MF A01 CSCL 07D

Precise control of crosslinking in the preparation of polyvinyl alcohol battery separators is achieved by incorporating the crosslinking agent in the polyvinyl alcohol and then effecting crosslinking after the polymer is shaped or fabricated into a useful configuration. Aqueous polyvinyl alcohol is admixed with an aqueous dialdehyde crosslinking agent. The pH of the solution is preferably alkaline to prevent premature crosslinking reaction. The aqueous admixture is cast into a sheet and dried to form a self-supporting film which is then immersed in an aqueous acid catalyst solution containing a dissolved salt in an amount sufficient to inhibit dissolution on taining a dissolved salt in an amount sufficient to inhibit dissolution containing a properties, such as low electrical resistivity, rendering the film suitable for use as a separator for an alkaline battery.

N79-16930°#. National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EVALUATION OF THE APPLICATION OF SOME GAS CHROMATOGRAPHIC METHODS FOR THE DETERMINA-TION OF PROPERTIES OF SYNTHETIC FUELS

Albert C. Antoine Jan 1979 46 p refs Presented at the Aerospace Meeting San Diego, Calif. 27-30 Nov. 1978, sponsored by the Soc of Automotive Engr

(NASA-TM-79035, E-9834) Avail NTIS HC A03/MF A01 CSCL 218

The purpose of the investigation was to evaluate the applicability, to some synthetic fuels, of some gas chromatographic methods now under development for use with petroleum based fuels. Thirty two jet and diesel fuel samples which were prepared from oil shale and coal syncrudes were examined. The boiling range distribution of each was determined by gas chromatography. and from that data distillation properties were calculated. The calculated results gave sufficient agreement ith the measured values that the equations could be useable in their present form Bulk fuel properties were calculated for the sixteen JP-5 and Diesel No 2 type fuels. The results show that the equations would not give useable results. Capillary column gas chromatography was used to determine the n-alkane content of the eight JP-5 type samples and the results related to the observed freezing points. The results show that the concentrations of the long straight chain molecules in the fuels exert influence on the freezing point but are not the complete controlling factor

N79-20200° Mational Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

PRELIMINARY EVALUATION OF THE ROLE OF K2S IN MHD HOT STREAM SEED RECOVERY Final Report

James Edward Bennett (Arkansas State Univ.) and Fred J. Kohl Mar 1979 24 p. refs

(Contract EF-77-A-01-2674)

(NASA-TM-79114, DOE/NASA/2674-79/1; E-9948). Avail NTIS HC A02/MF A01 CSCL 07D

Results are presented for recent analytical and experimental studies of the role of K2S in MHD hot stream seed recovery. The existing thermodynamic data base was found to contain large uncertainties and to be nonexistent for vapor phase K2S Knudsen cell mass spectrometric experiments were undertaken to determine the vapor species in equilibrium with K2S(c) K atoms and S2 molecules ere found to be the major vapor phase species in vacuum, accounting for greater than 99 percent or the vapor phase. Combustion gas deposition studies using No. 2 Diesel fuel were also undertaken and revealed that condensed phase K2SO3 may potentially be an important compound in the MHD stream at rear-stoichiometric combustion.

N79-22735\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

METHOD AND DEVICE FOR THE DETECTION OF PHENOL AND RELATED COMPOUNDS Patent

Julian G. Schiller (Pittsburgh Univ., Pa.) and Chung C. Liu, inventors (to NASA) (Pittsburgh Univ., Pa.) Issued 20 Mar. 1979 8 p. Filed 25 Feb. 1977. Supersedes N77-18238 (15 - 09, p. 1148) Sponsored by NASA.

(NASA-Case-LEW-12513-1, US-Patent-4,145,255,

US-Patent-Appl-SN-772167; US-Patent-Class-195-103.5R;

US-Patent-Class-195-127, US-Patent-Class-204-1T;

US-Patent-Class-2041-1958) Avail US Patent and Trademark Office CSCL 07D

A method is described which permits the selective oxidation and potentiometric detection of phenol and related compounds in an electrochemical cell. An anode coated with a gel immobilized oxidative enzyme and a cathode are each placed in an electrolyte solution. The potential of the cell is measured by a potentiometer connected to the electrodes.

Official Gazette of the U.S. Patent and Trademark Office

N79-22246°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CONTROL OF VOLUME RESISTIVITY IN INORGANIC ORGANIC SEPARATORS

Dean W Sheibley and Michelle A Manzo Apr. 1979 17 p. refs.

(NASA-TP-1439; E-9830) Avail: NTIS HC A02/MF A01 CSCL 07D

Control of resistivity in NASA inorganic-organic separators is achieved by incorporating small percentages of high surface area, fine particle silica with other ingredients in the separator coating. The volume resistivity is predictable from the surface area of filler particles in the coating. The approach is applied to two polymer- plasticizer -filler coating systems, where the filler content of each is below the generally acknowledged critical pigment volume concentration of the coating. Application of these coating systems to 0.0254 cm thick (10-mil) fuel cell grade asbestos sheet produces inexpensive, flexible, microporous separators that perform as well as the original inorganic-organic concept, the Astropower separator.

Author.

N79-25181\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

IMPROVED, LOW COST INORGANIC-ORGANIC SEPARA TORS FOR RECHARGEABLE SILVER-ZINC BATTERIES Dean W Sheibley Jun 1979 27 p refs

INASA-TP-1476 E-9930) Avail NTIS HC A03/MF A01 CSCL

Several flexible. low-cost inorganic-organic separators with performance characteristics and cycle life equal to, or better than the Lewis Research Center Astropower separator were developed. These new separators can be made an continuous-production equipment at about one-fourth the cost of the Astropower separator produced the same way. In test cells, these new separators demonstrate cycle life improvement, acceptable operating characteristics, and uniform current density. The various separator formulas, test cell construction, and data analysis are described.

N79-27279°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

MASS SPECTROMETRIC INVESTIGATION OF THE VAPOR-IZATION OF SODIUM AND POTASSIUM CHROMATES: PRELIMINARY RESULTS

Carl A Stearns, Fred J Kohl Robert A Miller, and George C Fryburg 1979 16 p refs Presented at the 8th Midwest High Temp Chem Conf. Milwaukee, 3-6 Jun. 1979

(NASA-TM-79210, E-095) Avail NTIS HC A02/MF A01

Knudsen cell mass spectrometry was used to study the vaporization of sodium and potassium chromates. For both salts, the vaporization proceeds predominately by the reactions M2CrO4(c) = 2M(g) + 5/4O2(g) + 1/2 Cr2O3(s) and M2CrO4(c) = M2CrO4(g) where M = Na or K. The distribution of the ions M(+), O2(+) and M2CrO4(+) in the measured mass

spectrum was found to depend on the material used for the Knudsen cell, even for materials such as platinum and gold. In the case of sodium chromate, the decomposition reaction appears to be less important than the molecular vaporization reaction. A preliminary value of 72 kcal/mole at 1141 K was measured for the heat of the molec 'ar vaporization reaction for sodium chromate. In the case of potassium chromate, it has not been possible to conclude which mode of vaporization dominates. For potassium chromate a value of 101 kcal/mole at 1173 K was obtained for the heat of the molecular vaporization reaction.

Author

N79-28258°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

THE ROLE OF NaCI IN FLAME CHEMISTRY, IN THE DEPOSITION PROCESS, AND IN ITS REACTIONS WITH PROTECTIVE OXIDES AS RELATED TO HOT CORROSION Fred J Kohl and Carl A. Stearns 1979 27 p refs Prepared for 4th Conf on Gas Turbine Materials in a Marine Environment, Annapolis, Md. 25-28 Jun 1979

(NASA-TM-79225, E-120) Avail NTIS HC A03/MF A01 CSCL 07D

Sodium chloride is believed to be the primary source of turbine engine contamination that contributes to hot corrosion. The behavior of NaCl-containing aerosols ingested with turbine intake air is very complex, some of the NaCl may vaporize during combustion while some may remain as particulates. The NaCl can lead to Na2SO4 formation by several possible routes or it can contribute to corrosion directly. Hydrogen or oxygen atom reaction with NaCl(c' was shown to result in the release of Na(g) Gaseous NaCl in flames can be partially converted to gaseous Na2SO4 by homogeneous reactions. The remaining gaseous NaCl and other Na-containing molecules can act as sodium carriers for condensate deposition of Na2SO4 on cool surfaces. A frozen boundary layer theory was developed to predict the rates of deposition. The condensed phase NaCl can be converted directly to condensed Na2SO4 by reaction with sulfur oxides and O2 Reaction of gaseous NaCl with Cr2O3 results in the vapor phase transport of chromium by the formation of complex Cr-containing gaseous molecules. Similar gaseous complexes are formed with molybdenum. The presence of gaseous NaCl was shown to affect the oxidation kinetics of Ni-Cr alloys It also causes changes in the surface morphology of Al2O3 scales formed on Al containing alloys

N79-31361\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

THE CHEMISTRY OF SODIUM CHLORIDE INVOLVEMENT IN PROCESSES RELATED TO HOT CORROSION

Carl A Stearns, Fred J Kohl, and George C Fryburg 1979 32 p. refs. Presented at the Conf. on Advanced Materials for Alternate Fuel Capable Directly Fired Heat Engines, Castine, Maine 30 Jul. - 3 Aug. 1979

(NASA-TM-79251, E-161) Avail NTIS HC A03/MF A01 CSCL 07D

Thermodynamic and mass transport calculations, and laboratory experiments elucidating the behavior of sodium chloride in combustion environments, in the deposition process, and in reactions with certain oxides on the surfaces of superalloys are summarized It was found that some of the ingested salt is separated out of the air stream by the compressor. However, sodium chloride does pass from the compressor to the combustor where numerous chemical reactions take place. Here some of the salt is vaporized to yield gaseous sodium chloride molecules. Hydrogen and oxygen atoms present in the combustion products react with some sodium chloride to yield other gaseous species such as sodium, and a fraction of the salt remains as particulates. Both the gas phase and condensed sodii. Il chloride can lead to sodium sulfate formtion by various routes, all of which involve reaction with sulfur oxides and oxygen. In addition to contributing to the formation of sodium sulfate, the sodium chloride can contribute to corrosion directly

A79-11542 \* # Effect of inlet temperature on the performance of a catalytic reactor. D. N. Anderson (NASA, Lewis Research Center, Cleveland, Ohio). U.S. Euvironmental Protection Agency, Workshop on Catalytic Combustion, 3rd, Asheville, N.C., Oct. 3, 4, 1978, Paper. 21 p. 17 refs. Contract No. EC-77-A-31-1040.

A 12-cm-diameter by 15-cm-long catalytic reactor was tested with No. 2 diesel fuel in a combustion test rig at inlet temperatures of 700, 800, 900, and 1000 K. Other test conditions included pressures of 300,000 and 600,000 Pa, reference velocities of 10, 15, and 20 m/s, and adiabatic combustion temperatures in the range from 1100 to 1400 K. The combustion efficiency was calculated from measurements of carbon monoxide and unburned hydrocarbon emissions. Nitrogen oxide emissions and reactor pressure drop were also measured. At a reference velocity of 10 m/s, the CO and unburned hydrocarbons emissions and, therefore, the combustion efficiency were independent of inlet temperature. At an inlet temperature of 1000 K, they were independent of reference velocity. Nitrogen oxides emissions resulted from conversion of the small amount of fuel-bound nitrogen in the fuel. Up to 90% conversion was observed with no apparent effect of any of the test variables. For typical gas-turbine operating conditions, all three pollutants were below levels which would permit the most stringent proposed automotive emissions standards to be met. (Author)

A79-11547 \* # Determination of the zincate diffusion coefficient and its application to alkaline battery problems. C. E. May and H. E. Kautz (NASA, Lewis Research Center, Cleveland, Ohio). Electrochemical Society, Meeting, 154th, Pittsburgh, Pa., Oct. 15-20, 1978, Paper, 19 p. 11 refs.

The diffusion coefficient for the zincate ion at 24 C was found to be  $9.9 \times 10$  to the -7th power sq cm/sec + or - 30% in 45% potassium hydroxide and  $1.4 \times 10$  to the -7th power sq cm/sec + or - 25% in 40% sodium hydroxide. Comparison of these values with literature values at different potassium hydroxide concentrations show that the Stokes-Einstein equation is obeyed. The diffusion coefficient is characteristic of the zincate ion (not the cation) and independent of its concentration. Calculations with the measured value of the diffusion coefficient show that the zinc concentration in an alkaline zincate half-cell becomes uniform throughout in tens of hours by diffusion alone. Diffusion equations are derived which are applicable to finite-size chambers. Details and discussion of the experimental method are also given.

A79-14956 \* # Correlations of catalytic combustor performance parameters. D. L. Bulzan (NASA, Lewis Research Center, Cleveland, Ohio). U.S. Environmental Protection Agency, Workshop on Catalytic Combustion, 3rd, Asheville, N.C., Oct. 3 4, 1978, Paper. 14 p. Contract No. EC-77-A-31-1040.

A 12 cm-diameter catalytic combustor test rig using propane fuel at an inlet temperature of 800 K, a pressure of 300,000 Pa, and reference velocities from 10 to 20 n/s was studied. Combustion efficiency at the test conditions is a function of the catalyst bed cell density, cell circumference, reactor length, and the reference velocity, the efficiency was also dependent on the adiabatic reaction temperature to the tenth power. The percentage pressure drop is proportional to the reference velocity to the 1.5 power and is also proportional to the reactor length and inversely proportional to the cell hydraulic diameter, fractional open area, and the pressure. The minimum adiabatic reaction temperature required to meet the emissions goals is proportional to the reference velocity to the 0.1 power and inversely proportional to the cell circumference, cell density, and reactor length to the 0.1 power. The parameters which are a function of a catalyst factor are reported.

M.L.

A79-19480 \* # Turbulence effects on flame speed and flame structure. K. O. Smith (NASA, Lowis Research Center, Cleveland, Ohio; Cornell University, Ithaca, N.Y.) and F. C. Gouldin (Cornell University, Ithaca, N.Y.). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0016. 10 p. 21 refs. Grant No. NsG-3019.

Turbulence effects on methane-air flames stabilized in grid turbulence were investigated through measurements of flame speed and mean and fluctuating flame temperature profiles. Published turbulent flame speed correlations were able to correlate the experimental flame speed data but were contradictory in indicating flame structure and combustion mechanisms. A simple, one-dimensional, wrinkled laminar flame model was used to predict characteristic flame temperature fluctuation levels. Comparison of these predictions with measured temperature fluctuations indicated that the majority of the flames studied were wrinkled laminar flames. However, a wrinkled laminar flame structure was inappropriate for the most intensely turbulent flames examined. (Author)

A79-19586 \* # Experimental study of the effects of flame-holder geometry on emissions and performance of lean premixed combustors. G. Roffe, K. S. Venkataramani (General Applied Sciences Laboratories, Inc., Westbury, N.Y.), and R. M. Duerr (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0187. 10 p. NASA-supported research.

Emissions of NOx, CO and unburned hydrocarbons (UHC) are reported for a lean premixed propane-air system at inlet conditions of 800K and 1 MPa using twelve flameholder designs. The flameholders tested represent six design concepts with two values of blockage for each concept. Data were obtained at reference velocities of 35 m/s, 25 m/s and 20 m/s at combustor stations 10 cm and 30 cm downstream of the flameholders. Flameholder pressure drop was found to be a principal determinant of emissions performance. Designs producing larger pressure drops also produced less NOx, CO and UHC emissions. The lean stability limit equivalence ratio was found to be approximately 0.35 for all designs. Flashback velocities (axial components in the flameholder passages) varied between 30 m/s and 40 m/s. A perforated plate flameholder was operated with a velocity as low as 23 m/s through the perforations at equivalence ratio 0.7 without producing flashback. (Author)

A79-217.22 \* # Ion chromatographic determination of sulfur in fuels. C. S. Mizisin, D. E. Kuivinen, and D. A. Otterson (NASA, Lewis Research Center, Cleveland, Ohio). U.S. Environmental Protection Agen: y. National Symposium on Ion Chromatographic Analysis of Environmental Pollutarts and Other Analogous Compounds, 2nd, Research Triangle Park, N.C., Oct. 11-13, 1978, Paper. 15 p. 9 ref.

A79.25917 \* Evaluation of the application of some gas chromatographic methods for the determination of properties of synthetic fuels. A. C. Antoine (NASA, Lewis Research Center, Cleveland, Ohio). Society of Automotive Engineers, Aerospace Meeting, San Diego, Calif., Nov. 27-30, 1978, Paper, 45 p. 6 refs.

The purpose of the investigation was to evaluate the applicability, to some synthetic fuels, of some gas chromatographic methods now under development for use with petroleum based fuels. Thirtytwo jet and diesel fuel samples which were prepared from oil shale and coal syncrudes were examined. The boiling range distribution of each was determined by gas chromatography, and from that data distillation properties were calculated. The calculated results gave sufficient agreement with the measured values that the equations could be useable in their present form. Bulk fuel properties were calculated for the 16 JP-5 and Diesel No. 2 type fuels. The results show that the equations would not give useable results. Capillary column gas chromatography was used to determine the n-alkane content of the eight JP-5 type samples and the results related to the observed freezing points. The results show that the concentrations of the long straight chain molecules in the fuels exert influence on the freezing point but are not the complete controlling factor. (Author)

A79-26374 Burn coal cleanly in a fluidized bed - The key is in the controls. J. A. Kobak (NASA, Lewis Research Center, Cleveland, Ohio). Insulaments and Control Systems, Jan. 1979, p. 29-32

The fluidized-bed combustion (FBC) process produces few sulfur emissions, and can burn wood, municipal solid waste as well as every kind of coal available in the U.S. The presurized, coal-burning fluidized-bed reactor at NASA's Lewis Research Center is described, together with a discussion of the operating results. The FBC system at '\_ewis, having a completely instrumented reactor, is used to test turbine blade alloys for future power plant applications. With the same type of coal and limestone used in the first testing phase covering 136 hours, it was found that all NOx values were below the EPA standard 0.7 lb/MBtu, whereas the maximum observed level of SO2 was above the EPA standard of 1.3 lb/MBtu, but with the average SO2 level, however, only 0.63 lb/MBtu. Unburned hydrocarbon and CO levels were very low, indicating combustion efficiencies of close to 99% in almost all tests. Testing is now underway using high temperature cyclones and gas turbine to eliminate erosion and corrosion effects which were observed after the initial tests on the turbine and blades.

A79-26546 \* Effect of a chromium-containing fuel additive on hot corrosion. C. E. Lowell and D. L. Deadmore (NASA, Lewis Research Center, Cleveland, Ohio). *Corrosion Science*, vol. 18, 1978, p. 747-749, 751-759, 761-763. 8 refs.

Four cast superalloys (one cobalt-base and three nickel-base) were tested at 900 C for 100 h in Mach 0.3 combustion gases. 5 ppm of synthetic sea salt were added to the gases in the combustion chamber. Several types of thermal cycle and washing procedures were employed. Similar tests were made with the addition of 300 ppm of a chromium-containing fuel additive. In both sets of tests the extent of hot corrosion was evaluated by specific weight change and metal recession. In general, the chromium additive in the fuel reduced the extent of hot (salt) corrosion but did not eliminate it. The percentage reduction of hot corrosion attack was similar for all four alloys. As great a reduction of hot corrosion was achieved by reducing the number of thermal cycles during the test from 100 to 5 or 6. The effect of washing the alloys every ten cycles as opposed to the end of the test was erratic; some alloys were attacked slightly more, others somewhat less. A NiCrAlY coating was found to be more effective in reducing hot corrosion than either the fuel additive (Author) or the washing schedule.

A79-39036 \* # Effect of degree of fuel vaporization upon emissions for a premixed prevaporized combustion system. L. P. Cooper (NASA, Lewis Research Center, Cleveland, Ohio). A/AA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, A/AA Paper 79-1320 13 p. 20 refs.

An experimental and analytical study of the combustion of partially vaporized fuel air mixtures was performed to assess the impact of the degree of fuel vaporization upon emissions for a premixing-prevaporizing flametube combustor. Data collected showed near-timear increases in NOx emmissions with decreasing vaporization at equivalence ratios of 0.6. For equivalence ratios of 0.72, the degree of vaporization had very little impact on NOx emissions. A simple mechanism which accounts for the combustion of liquid droplets in partially vaporized mixtures was found to agree with the measured results with fair accuracy with respect to both trends and magnitudes. (Author)

A79-46366 \* Resonance-tube ignition of aluminum. B. R. Phillips (NASA, Lewis Research Center, Cleveland, Ohio) and K. J. de Witt (Toledo, University, Toledo, Ohio). Combustion and Flame, vol. 35, Aug. 1979, p. 249-258. 12 refs

An experimental program was carried out to determine whether spontaneous fluid-dynamic oscillations could create a hazard in gaseous oxygen flow systems by igniting metal contaminants. The particular fluid-dynamic oscillation studied was the resonance-tube phenomenon, as it was excited in a tee-shaped configuration.

representative of configurations found in many industrial flow systems. Pure aluminum was chosen as the candidate material for ignition. The oscillations in the tee-shaped configuration were compared with oscillations driven by choked convergent nozzles and were found to differ markedly. The temperatures generated at the base of the resonance tube were well in excess of 1000 F for both gaseous oxygen and nitrogen. The effect of inert particulate matter introduced into the resonance tube was to increase significantly the measured temperatures. Aluminum in both powder and fiber form was readily ignited within the resonance tube at pressures less than 1200 psia. At higher pressures, the aluminum-oxygen mixture exploded. This investigation confirms the hazardous nature of resonance-tube oscillations as generated in typical piping configurations that use high-pressure oxygen. (Author)

A79-49533 \* # Mass spectrometric investigation of the vaporization of sodium and potassium chromates - Preliminary results. C. A. Stearns, F. J. Kohl, R. A. Miller, and G. C. Fryburg (NASA, Lewis Research Center, Cleveland, Ohio). Midwest High Temperature Chemistry Conference, 8th, Milwaukee, Wis., June 3-6, 1979, Paper. 14 p. 17 refs.

A79-49634 \* # The role of NaCl in flame chemistry, in the deposition process, and in its reactions with protective oxides as related to hot corrosion. F. J. Kohl, C. A. Stearns, and G. C. Fryburg (NASA, Lewis Research Center, Cleveland, Chio). Conference on Gas Turbine Materials in a Marine Environment, 4th, Annapolis, Md., June 25-28, 1979, Paper. 26 p. 61 refs.

N79-10165°# General Applied Science Labs Inc., Westbury, N Y

EMISSION MEASUREMENTS FOR A LEAN PREMIXED PROPANE/AIR SYSTEM AT PRESSURES UP TO 30 ATMOSPHERES Final Report

Gerald Roffe and K. S. Venkataramani. Jun. 1978. 41 p. ref. (Contract NAS3-20603).

(NASA-CR-159421, GASL-TR-250) Avail NTIS HC A03/MF A01 CSCL 21B

The emissions of a lean premixed system of propane/air were measured in a flametube apparatus. Tests were conducted at inlet temperatures of 600K and 800K and pressures of 10 atm and 30 atm over a range of equivalence ratios. The data obtained were combined with provious data taken in the same apparatus to correlate nitrogen oxide emissions with operating conditions. Sampling probe design was found to have a pronounced effect on measured. CO levels but did not influence measurements. The most effective probe tested was one which combined thermal and pressure quenching of the gas sample.

N79-22243\*# United Technologies Research Center, East Hartford, Conn.

LEAN STABILITY AUGMENTATION STUDY Final Report John B. McVey and Jan B. Kennedy May 1979 185 p refs (Contract NAS3-20804)

(NASA-CR-159536; UTRC/R79-914104-18) Avail. NTIS HC A09/MF A01 CSCL 21B

An analytical conceptual design study and an experimental test program were conducted to investigate techniques and develop technology for improving the lean combustion limits of premixing, prevaporizing combustors applicable to gas turbine engine main burners. The use of hot gas pilots, catalyzed "meholder elements, and heat recirculation to augment lean acability limits was considered in the conceptual design study. Tests of flameholders embodying selected concepts were conducted at a pressure of 10 arm and over a range of entrance temperatures simulating conditions to be encountered during stratospheric cruise. The tests were performed using an axisymmetric flametube test rig having a nominal diameter of 10.2 cm. A total of sixteen test configurations were examined in which lean blowout limits, pollutant emission characteristics, and combustor performance were evaluated.

perforated plate flameholder employing a pilot fuel flow rate equivalent to 4 percent of the total fuel flow at a simulated cruise condition resulted in a lean blowout equivalence ratio eless than 0.25 with a design point (T sub zero = 600k, Phi = 0.6) NOx emission index of less than 1.0 g/kg.

N79-23168\*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.

MEASUREMENTS OF ADMITTANCES AND CHARACTERISTIC COMBUSTION TIMES OF REACTIVE GASEOUS PROPELLANT COAXIAL INJECTORS

B. A. Janardan, B. R. Daniel, and B. T. Zinn. Mar. 1979 78 p. refs.

(Grant NsG-3052)

(NASA-CR-159542) Avail: NTIS HC A05/MF A01 CSCL 21B

The results of an experimental investigation that was concerned with the quantitative determination of the capabilities of combustion processes associated with coaxial injectors to amplify and sustain combustor oscillations was described. The driving provided by the combustion process was determined by employing the modified standing-wave method utilizing coaxial injectors and air-acetylene mixtures. Analyses of the measured data indicate that the investigated injectors are capable of initiating and amplifying combustion instabilities under favorable conditions of injector-combustion coupling and over certain frequency ranges. These frequency ranges and the frequency at which an injector's driving capacity is maximum are observed to depend upon the equivalence ratio, the pressure drop across the injector orifices and the number of injector elements. The characteristic combustion times of coaxial injectors were determined from steady state temperature measurements

N79-25178\*# Case Western Reserve Univ., Cleveland, Ohio X-RAY PHOTOELECTRON SPECTROSCOPY STUDY OF NICKEL AND NICKEL-BASE ALLOY SURFACE ALTERATIONS IN SIMULATED HOT CORROSION CONDITIONS WITH EMPHASIS ON EVENTUAL APPLICATION TO TURBINE BLADE CORROSION Final Report

Gheorghe D Mateescu and Staven R Smith Jun. 1979 49 p. refs.

(Grant NsG-3009)

(NASA-CR-159553) Avail NTIS HC A03/MF A01 CSCL 07D

Research on the high temperature oxidation and Na2SO4 induced hot corrosion of some nickel base superalloys was accomplished by using ESCA to determine the surface composition of the oxidized or corroded samples. Oxidation was carried out at 900 or 1000 C in slowly flowing 02 for samples of B-1900. NASA TRW VIA. 713C. and IN-738. Oxidation times ranged from 0.5 to 100 hr. Hot corrosion of B-1900 was induced applying a coating of Na2SO4 to peroxidized samples, the heating to 900 C in slowly flowing 02 For oxidized samples, the predominant type of scale formed by each superalloy was determined, and a marked surface enrichment of Ti was found in each case. For corroded samples the transfer of significant amounts of material from the oxide layer to the surface of the salt layer was observed to occur long before the onset of accelerating weight-gain Changes in surface composition were observed to coincide with the beginning of accelerating corrosion, the most striking of which was a tenfold decrease in the sulfur to sodium ration and an increase in the CriVII ratio Author

N79-25183\* Yale Univ New Haven Conn High Temperature Chemical Reaction Engineering Lab

EXPERIMENTAL STUDIES OF THE FORMATION/ DEPOSITION OF SODIUM SULFATE IN/FROM COMBUS-TION GASES Semiannual Report, 16 Nov. 1977 - 15 May

Daniel E. Rosner 15 May 1978 14 p. refs (Grant NsG-3169)

INASA CR 159612 SAR 11 Avail NTIS HC A02/MF A01 CSCL 218

Processes related to the hot corrosion of gas turbine components were examined in two separate investigations

Monochromatic laser light was used to probe condensation onset and condensate film growth (via interference of reflected light) on electrically heated ribbons immersed in seeded, flat flame combustion product gases. Boron trichloride is used as the seed gas in these preliminary experiments conducted to obtain precise measurements of the dew point/deposition rates. Because of the importance of gaseous Na(g) as a precursor to NaSO4 formation, the kinetics and mechanisms of the heterogeneous reaction H(g) + NaCl(s) yields Na(g) + HCl(g) was studied using atomic absorption spectroscopy combined with microwave discharge-vacuum flow reactor techniques at moderate temperatures. Preliminary results indicate the H-atom attack of solid NaCl vaporization is negligible, hence the corresponding gas phase (homogeneous) reaction no role in the observed Na(g) production.

N79-31358\* General Electric Co., Cincinnati, Ohio, LEAN, PREMIXED-PREVAPORIZED (LPP) COMBUSTOR CONCEPTUAL DESIGN STUDY Final Report

R. A. Dickman, W. J. Dodds, and E. E. Ekstedt. May 1979 152 p. refs.

(Contract NAS3-21255)

(NASA-CR-159629. R79AEG376) Avail NTIS HC A08/MF A01 CSCL 21B

Four combustion systems were designed and sized for the energy efficient engine. A fifth combustor was desiged for the cycle and envelope of the twin-spool, high bypass ratio, high pressure ratio turbofan engine. Emission levels, combustion performance, life, and reliability assessments were made for these five combustion systems. Results of these design studies indicate that cruise. NOx emission can be reduced by the use of lean, premixed-prevaporaized combustion and airflow modulation.

Author

N79-32303\*# Notre Dame Univ., Ind Dept. of Aerospace and Mechanical Engineering.

FEASIBILITY STUDY OF LIQUID POOL BURNING IN REPUCED GRAVITY Final Report, Jul. 1977 - Feb. 1979 A. Murty Kanury Sep. 1979 79 p. refs (Contract NAS3-21018)

(NASA-CR-159642, TR-79-1) Avail NTIS HC A05/MF A01 CSCL 21B

The feasibility of conducting experiments in the Spacelab on ignition and flame spread with liquid fuel pools which are initially at a temperature lower than the fuels flash point temperature was studied. Theories were developed for the ignition and flame spread processes, and experiments were conducted to understand the factors influencing the ignition process and the spread rate. The results were employed to devise a conceptual Spacelab experiment which is expected to be leasible for a safe conduct and to be suitable for obtaining crucial data on the concerned processes.

N79-33288\* # State Univ of New York at Stony Brook
COMBUSTION OF POROUS SOLIDS AT REDUCED
GRAVITATIONAL CONDITIONS Final Report

A L Berlad and J. Killroy Washington NASA Oct. 1979 110 p. refs

(Grant NsG-3051)

(NASA-CR-3197) Avail NTIS HC A06/MF A01 CSCL 218 A ground-based experimental and analytic study considered the utility and that feasibility of a space shuttle-based experimental study of the combustion of porous solids at reduced gravitational conditions. This ground-based study employed the Lewis Research Center's g = 0 (drop tower) facility. Experimental g = 1 studies were performed both at the Lewis Research Center and at State University of New York at Stony Brook. It is found that the considered space shuttle-based experimental program is expected to yield vital fundamental combustion information that is not obtainable from earth-bound studies alone. The considered space shuttle-based study is entirely feasible and a detailed approach to these experiments is presented.

#### 26 METALLIC MATERIALS

Includes physical, chemical, and mechanical properties of nietals, e.g., corrosion, and metallurgy.

N79-1:179\*# National Aerorautics and Space Administration Lewis Research Center Cleveland, Ohio

THERMAL BARRIER COATINGS: BURNER RIG HOT CORROSION TEST RESULTS Final Report

Philip E Hodge Stephen Stecura, Michael A Gedwill, Isidor Zaplatynsky, and Stanley R Levine Oct 1978 35 p refs (Contract EF 77 A 01-2593)

(NA SA TM 79005 E 9787 DOE/NASA/2593-78/3) Avail NTIS HC A03/MF A01 CSCL 11F

A Mach 0.3 burnering test program was conducted to examine the sensitivity of thermal barrier coatings to Na and V contaminated combustion gases simulating potential utility gas turbine environments. Coating life of the standard ZrO2 12Y2O3/Ni-16 2Cr-5 6AI 0.6Y NASA thermal barrier coating system which was developed for aircraft gas turbines was significantly reduced in such environments. Two thermal barrier coating systems, Ca25iO4/Ni-16 4Cr-5 6AI 0.6Y and ZrO2 8Y2O3/Ni-16 4Cr-5 1AI 0.15Y and a less insulative cermet coating system, 50 volume percent MgO 50 volume percent Ni-19 6Cr-17 1AI-0.97Y/Ni-16 C2r-5 6AI 0.6Y were identified as having much improved corrosion resistance compared to the standard coating. Author

N79-12201\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

THE EFFECT OF NITROGEN ION (N(+)) IMPLANTATION ON THE FRICTION AND WEAR CHARACTERISTICS OF IRON

William R. Jones, Jr and John Ferrante Nov. 1978 18 p

(NASA-TM-79029 E-9824) Avail NTIS HC A02/MF A01 CSCL 11F

The friction and wear properties of pure iron sliding against M:-50 steel were not significantly altered after nitrogen implantation. The unimplanted iron exhibited an average wear rate of 1.47  $\pm$  or  $\pm$  0.27 M to the third power/N-M compared to 1.53  $\pm$  or  $\pm$  0.73 for the nitrogen implanted iron. Average friction coefficients were 0.10 (unimplanted) and 0.09 (implanted). G.G.

N79-12203\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

FRETTING WEAR OF IRON, NICKEL, AND TITANIUM UNDER VARIED ENVIRONMENTAL CONDITIONS

Robert C. Bill, (AVRADCOM Res and Technol. Labs.) 1978 30 p. refs. Proposed for presentation at the Intern. Conf. Wear o. Mater. Dearborn, Mich., 16-18. Apr. 1979, sponsored by ASME, ASLE, ASM, ASTM-62, SAE, SME, Am. Chem. Soc., All 15, and APS.

(NASA-TM-78972, AVRADCOM-TR-78-59, E-9745) Avail NTIS HC A03/MF A01 CSCL 11F

Fretting wear experiments were conducted on high purity iron, nickel and titanium in air under conditions of varied humidity and temperature, and in nitrogen. For iron and titanium, maximum fretting occurred at 1' and 30 percent relative humidity respective'y. Nici all showed a minimum in fretting wear at about 10 percent relative humidity. With increasing temperature all three metals initial' showed reduced fretting wear, with increasing wear observed as temperatures increased beyond 200-300 C. For titanium, dramatically reduced fretting wear was observed at temperatures above 500 C, relatable to a change in oxidation kinetics. All three metals showed much less fretting wear in N2 with the presence of moisture in N2 having a proportionally stronger effect than in air.

Author

N79-12204\* National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio WEAR OF SEAL MATERIALS USED IN AIRCRAFT PROPULSION SYSTEMS.

Robert C. Bill and Lawrence P. Ludwig 1978 30 p refs Presented at the Mater, and Processing Congr., Philadelphia, 7-9 Nov. 1978 Prepared in cooperation with Army Aviation Research and Development Command, St. Louis, Mo.

(NASA-TM-79003: E-9789; AVRADCOM-TR-78-47) Avail NTIS HC A03/MF A01 CSCL 11F

The various types of seal locations in a gas turbine engine are described, and the significance of wear to each type is reviewed. Starting with positive contact shaft seals, existing material selection guidelines are reviewed, and the existing PV (contact pressure X sliding velocity) criteria for selecting seal materials are discussed, along with the theoretical background for these criteria. Examples of wear mechanisms observed to operate in positive contact seals are shown. Design features that can extend the operating capabilities of positive contact seals, including pressure balancing and incorporation of hydrodynamic lift are briefly discussed. It is concluded that, despite the benefits arising from these design features, improved positive contact seal materials from the standpoint of wear, erosion and oxidation resistance will be necessary for further improvements in seal performance and durability, and to meet stringent future challenges.

N79-12205\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SHEAR RUPTURE OF A DIRECTIONALLY SOLIDIFIED EUTECTIC GAMMA/GAMMA PRIME - ALPHA (Mo) ALLOY

Fredric H. Harf 1978 15 p refs Presented at the Conf. on In-Situ Composites 3, Boston, 27 Nov. - 1 Dec. 1978; sponsored by the Mater. Res. Soc.

(NASA-TM-79038; E-9840) Avail NTIS HC A02/MF A01 CSCL 11F

Directionally solidified Mo alloys are evaluated to determine the shear rupture strength and to possibly improve it by microstructural and heat treatment variations. Bars of the alloy containing nominally 5.7% Al and 33.5% Mo by weight with balance Ni were directionally solidified at rates between 10 and 100 mm per hour in furnaces with thermal gradients at the liquid-solid interface of 250 or 100 C per cm. A limited number of longitudinal shear rupture tests were conducted at 760 C and 207 MPa in the as - solidified and in several heat treated conditions. It is shown that shear rupture failures are partly transgranular and that resistance to failure is prompted by good fiber alignment and a matrix structure consisting mainly of gamma prime Well aligned as - solidified specimens sustained the shear stress for an average of 81 hours. A simulated coating heat treatment appeared to increase the transformation of gamma to gamma prime and raised the average shear life of aligned specimens to 111 hours. However, heat treatments at 1245 C. and especially at 1190 C appeared to be detrimental by causing partial solutioning of the gamma prime, and reducing lives to 47 and 10 hours, respectively

N79-19145\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HIGH TOUGHNESS-HIGH STRENGTH IRON ALLOY Patent Application

J. R. Stephens and W. R. Witzke, inventors (to NASA) 25 Jan 1979 11 p.

(NASA-Case-LEW-12542-3. US-Patent-Appl-SN-007083) Avail NTIS HC A02/MF A01 CSCL 11F

N79-20216\*# National Aeronautics a d Space Administration. Lewis Research Center, Cleveland, Ohio.

#### CRITICAL MASS FLUX THROUGH SHORT BORDA TYPE INLETS OF VARIOUS CROSS SECTIONS

R. C. Hendricks and N. P. Poolos (Lake Ridge Academy, North Ridgeville, Ohio) 1979 26 p refs To be presented at the 15th Intern. Congr. of Refrigeration, Venice, 23-29 Sep. 1979: sponsored by the Intern. Inst. of Refrigeration

(NASA-TM-79017; E-9868) Avail: NTIS HC A03/MF A01 CSCL 11F

Mass flux measurements associated with chocked flows through four Borda type inlet geometries: circular, square, triangular and rectangular (two-dimensional) and two sharp edged geometries taken over a very wide range of inlet stagnation conditions. The measurements indicate that: (1) the mass flux is independent of the inlet cross-section geometry and (2) the mass flux is dependent only on the inlet stagnation conditions. Also by using choked flow results found in the literature, the reduced mass flux is independent of working fluid. Two implications are drawn which remain to be verified: (1) since seal leak rates are weakly dependent on geometry but pressure distribution is strongly dependent on geometry, seal design efforts should be directed more toward controlling the dynamics, and (2) high-L/D ducts of arbitrary cross section and Borda type inlets can possess free jets.

N79-20217\* Mational Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### EVALUATION OF A BRAYTON CYCLE RECUPERATOR AFTER 21,000 HOURS OF GROUND TESTING

Thomas J. Moore Feb. 1979 28 p refs

(NASA-TM-79091; E-9915) Avail: NTIS HC A03/MF A01 CSCL 11F

A metallographic examination was conducted on a Brayton cycle recuperator and associated ducting after 21,000 hours of ground testing in air. At the hot (turbine) end, the recuperator operated at a nominal temperature of 675 C. The type 347 stainless-steel recuperator performed satisfactorily in the ground test even though the primary working fluid leaked to the atmosphere periodically. The leakage path was located at plate-bar braze joints which cracked as a result of thermal stresser. The welded type 347 stainless steel ducting a type 347/Hastelloy X bellows survived the ground test with no apparent loss of ductility or integrity. Some apparent aging embrittlement was observed in the Hastelloy X ducting but the serviceability was not

Lewis Research Center, Cleveland, Ohio.

#### CHARACTERIZATION OF DEFECT GROWTH STRUCTURE IN ION PLATED FILMS BY SCANNING ELECTRON MICROSCOPY

Talivaldis Spalvins 1979 12 p refs Presented at the Intern. Conf. on Met. Coatings, San Diego, Calif., 23-37 Apr. 1979; sponsored by Am. Vacuum Soc.

(NASA-TM-79110, E-9528) Avail NTIS HC A02/MF A01 CSCL 11F

Copper and gold films (0 2 to 2 microns) were ion plated onto polished 304-stainless-steel surfaces. These coatings were examined by scanning electron microscopy for coating growth defects. Three types of defects were distinguished: nodular gr. wth. abnormal or runaway growth, and spits. The cause and origin for each type of defect was traced. Nodular growth is primarily due to inherent substrate microdefects, abnormal or runaway growth is due to external surface inclusions, and spits are due to nonuniform evaporation. All these defects have adverse effects on the coatings. They induce stresses and produce porosity in the coatings and thus weaken their mechanical properties. Friction and wear characteristics are affected by ng defects. since the large nodules are pulled out and additional wear debris is generated Author

N79-20220\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### ADHERENCE OF SPUTTERED TITANIUM CARBIDES

William A. Brainard and Donald R. Wheeler 1979 10 p refs Presented at the Intern. Conf. on Met. Coatings, San Diego, Calif., 23-27 Apr. 1979

(NASA-TM-79117; E-9950) Avail: NTIS HC A02/MF A01 CSCL 11F

Sputtered coatings of the refractory metal carbides are of great interest for applications where hard wear-resistant materials are desired. The usefulness of sputtered refractory carbides is often limited in practice, by spalling or interfacial separation. In this work improvements in the adherence of refractory carbides on iron, nickel and titanium based alloys were obtained by using oxidation, reactive sputtering or sputtered interlayers to alter the coating-substrate interfacial region. X-ray photoelectron spectroscopy and argon ion etching were used to characterize the interfacial regions, and an attempt was made to correlate adherence as measured in wear tests with the chemical nature of the interface. Author

N79-21184°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### WEAR OF ALUMINUM AND HYPOEUTECTIC ALUMINUM-SILICON ALLOYS IN BOUNDARY-LUBRICATED PIN-ON DISK SLIDING

John Ferrante and William A. Brainard Apr. 1979 27 p refs (NASA-TP-1442; E-9809) Avail: NTS HC A03/MF A01 CSCL

The friction and wear of pure aluminum and a number of hypoeutectic aluminum-silicon alloys (with 3 to 12 wt %Si) were studied with a pin-on-disk apparatus. The contacts were lubricated with mineral oil and sliding was in the boundary-lubrication regime at 2.6 cm/sec. Surfaces were analyzed with photomicrographs, scanning electron microscopy, X-ray dispersive analysis, and diamond pyramid hardness measurements. There were two wear regimes for the alloys - high and low - whereas pure aluminum exhibited a high wear rate throughout the test period. Wear rate decreased and the transition stress from high to low wear increased with increasing hardness. There was no correlation between friction coefficient and hardness. A least squares curve fit indicated a wear-rate dependence greater than the inverse first power of hardness. The lower wear rates of the alloys may be due to the composites of silicon platelets in aluminum resulting in increased hardness and thus impairing the shear of the Author

N79-22271\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### PROCESS FOR MAKING A HIGH TOUGHNESS-HIGH STRENGTH ION ALLOY Patent

Joseph R. Stephens and Walter R. Witzke, inventors (to NASA) Issued 27 Mar. 1979 4 p Filed 13 Dec. 1977 Supersede; N78-22205 (16 - 13. p 1681) Division of US Patent Appl. SN-803822, filed 6 Jun 1977

NASA-Case-LEW-12542-2, US-Patent-4,146,409.

US-Patent-Appl-SN-860405, US-Patent-Class-148-2;

US-Patent-Class-148-12F, US-Patent-Class-148-12.4;

US-Patent-Appl-SN-803822) Avail US Patent and Trademark

A steel alloy is produced by a process which includes using cold rolling at room temperature and subsequent heat treatment at temperatures ranging from 500 C to 650 C. The resulting alloys exhibits excellent strength and toughness characteristics at cryogenic temperatures. This alloy consists essentially of about 10 to 16 percent by weight nickel, to about 1.0 percent by weight aluminum, and 0 to about 3 percent by weight of at least one of the following additional elements copper, lanthanum, niobium, tantalum, titanium, vanadium, yttrium, zirconium and the rare earth metals, with the balance being essentially iron. The improved alloy possesses a fracture toughness ranging from 200 to 230 ksi sq in, and yield strengths up to 230 ksi.

Official Gazette of the U.S. Patent and Trademark Office

N79-22274° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE FRICTION AND WEAR OF METALS AND BINARY ALLOYS IN CONTACT WITH AN ABRASIVE GRIT OF SINGLE-CRYSTAL SILICON CARBIDE

Kazuhisa Miyoshi and Donald H. Buckley 1979 28 p refs Proprised for presentation at the Joint Lubrication Conf., Dayton, Ohio, 16-18 Oct. 1979, cosponsored by Am. Soc. of Lubrication Engr. and ASME

(NASA-TM-79131; E-9973) Avail: NTIS HC A03/MF A01 CSCL 11F

Sliding friction experiments were conducted with various metals and iron-base binary alloys (alloying elements Ti, Cr, Mn, Ni, Rh and W) in contact with single crystal silicon carbide riders. Results indicate that the friction force in the plowing of metal and the groove height (corresponding to the wear volume of the groove) decrease linearly as the shear strength of the bulk metal increases. The coefficient of friction and groove height generally decrease, and the contact pressure increases with an increase in solute content of binary alloys. There appears to be very good correlation of the solute to iron atomic ratio with the decreasing rate of change of coefficient of friction, the decreasing rate of change of groove height and the increasing rate of change of contact pressure with increasing solute content. These rates of change increase as the solute to iron atomic radius ratio increases or decreases from unity.

Author

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THE STRAINRANGE PARTITIONING BEHAVIOR OF AN ADVANCED GAS TURBINE DISK ALLOY, AF2-1DA

G. R. Halford and A. J. Nachtigall 1979 11 p refs Presented at the 15th Joint Propulsion Conf., Las Vegas, 18-20 Jun. 1979; cosponsored by AIAA, the Soc. of Automotive Engr., and ASME (NASA-TM-79179, E-046) Avail: NTIS HC A02/MF A01 CSCL 11F

The low-cycle, creep-fatigue characteristics of the advanced gas turbine disk alloy, AF2-1DA have been determined at 1400 F and are presented in terms of the method of strainrage partitioning (SRP). The mean stresses which develop in the PC and CP type SRP cycles at the lowest inclastic strainrange were observed to influence the cyclic lives to a greater extent than the creep effects and hence interfered with a conventional interpretation of the results by SRP. A procedure is proposed interpretation with the mean stress effects on life which is compatible with SRP.

Author

N79-25195\* Mational Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio METAL-DIELECTRIC INTERACTIONS

Donald H. Buckley 1979 24 p. refs. Presented at Conf. on Electrical Insulation and Dielectric Phenonena, Whitehaven, Pa., 21-25 Oct. 1979, sponsored by NRC.

(NASA-TM-79151) Avail NTIS HC A02/MF A01 CSCL

Metal direlectric surface interactions and dielectric films on metal substrates were investigated. Since interfacial interaction depends so heavily on the nature of the surfaces, analytical surface tools such as Auger emission spectroscopy, X-ray photoelectron spectroscopy and field ion microscopy were used to assist in surface and interfacial characterization. The results indicate that with metals contacting certain glasses in the clean state interfacial, bonding produces fractures in the glasses while when a film such as water is present, fractures occur in the metal near the interface. Friction forces were used to measure the interfacial bond strengths. Studies with metals contacting polymers using field ion microscopy revealed that strong bonding forces could develop being between a metal and polymer surface with polymer transferring to the metal surface in various ways depending upon the forces applied to the surface in contact With the deposition of refractory carbides, silicides and borides onto metal and alloy substrates the presence of oxides at the interface or active gases in the deposition plasma were shown to alter interfacial properties and chemistry. Auger ion depth profile analysis indicated the chemical composition at the interface and this could be related to the mechanical, friction, and wear behavior of the coating.

N79-29292\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EXPERIMENTAL, LOW-COST, SILICON SLURRY/ ALUMINIDE HIGH-TEMPERATURE COATING FOR SUPER-ALLOYS

Stanley G. Young and Daniel L. Deadmore Jul 1979 24 p. refs.

(NASA-TM-79178; E-045) Avail: NTIS HC A02/MF A01 CSCL

A duplex silicon-slurry/aluminide coating has been developed and cyclically tested in Mach 1 combustion gases for oxidation and thermal fatigue resistance at 1093 C and in Mach 0.3 gases for hot-corrosion resistance at 900 C. The base-metal superalloys were VIA and B-1900. The coated B-1900 specimens performed much better in oxidation than similar specimens coated with aluminides and almost as well as the more-expensive Pt-Al and McrAlY (where M is Ni and/or Co) coatings deposited by the physical vapor deposition process. The coating also provided good hot-corrosion protection. Metallographic, X-ray, and electron microprobe studies were made to characterize the coating, determine failure mechanisms, and study some of the changes due to exposure.

N79-29293\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

EFFECTS OF YTTRIUM, ALUMINUM, AND CHROMIUM CONCENTRATIONS IN BOND COATINGS ON THE PERFORMANCE OF ZIRCONIA-YTTRIA THERMAL BARRIERS

Stephan Stecura Jul. 1979 30 p refs (NASA-TM-79206, E-091) Avail. NTIS HC A03/MF A01 CSCL

A cyclic furnace study was conducted between 990 - 280 C and 1095 - 280 C to evaluate the effects of yttrum, chromium, and aluminum concentrations in nickel base alloy bond coatings and also the effect of the bond coating thickness on the performance of yttria-stabilized zirconia thermal barrier coatings. The presence and the concentration of yttrium is very critical Without yttrium, rapid oxidation of Ni-Al. Ni-Cr. and Ni-Cr-Al bond coatings causes zirconia thermal barrier coatings to fail very rapidly. Concentrations of chrominum and aluminum in Ni-Cr-Al-Y bond coating have a very significant effect on the thermal barrier coating life. This effect, however, is not as great as that due to yttrium. Furthermore, the thickness and the thickness uniformity also have a very significant effect on the life of the thermal barrier system.

N79-30355\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TRANSVEPSE AND LONGITUDINAL TENSILE PROPERTIES AT 780 C OF SEVERAL OXIDE DISPERSION STRENGTHEN-ED NICKEL-BASE ALLOYS

Albert E Anglin, Jr 1979 24 p refs Presented at Meeting of the Metallurgical Soc of the Am Inst of Mining, Metallurgical, and Petroleum Engineers. New Orleans, La. 18-20 Feb. 1979 (NASA-TM-79189, E-058) Avail NTIS HC A02/MF A01 CSCL 11F

The transverse and longitudinal tensile properties of the oxide dispersion strengthened nickel base alloys MA-793, MA-754. MA-755E, and MA-6000E were determined at 760 C. Transverse tensile strengths were comparable to longitudinal strengths. Transverse ductility levels generally were less than two percont elongation. Both tensile and yield strengths increased with increasing strain rate over the range 0.001 to 0.05 per second. Ductility was not strain rate sensitive, but related to grain size and grain aspect ratio. The fracture mode of most alloys changed from transgranular for longitudinally oriented specimens to intergranular for transverse specimens. Transverse properties of DM MAR M-200. His were also determined for comparison.

Author

N79-30356°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

# THE EROSION/CORROSION OF SMALL SUPERALLOY TURBINE ROTORS OPERATING IN THE EFFLUENT OF A PFB COAL COMBUSTOR

G. R. Zellars, S. M. Benfold, A. P. Rowe, and C. E. Lowell 1979 27 p. Presented at the Advanced Mater. for Alternate Fuel Capable Directly Fired Heat Engines Conf., Castine. Maine, 30 Jul. - 3 Aug. 1979; cosponsored by DOE and EPRI (NASA-TM-79227; E-125) Avail: NTIS HC A03/MF A01 CSCL 11F.

Superalloy turbine rotors in a single stage turbine with 6 percent partial admittance were operated in the effluent of a pressurized fluidized bed coal combustor for up to 164 hours. Total mass flow was 300 kg/hr and average particulate loadings ranged from 600 to 2800 ppm for several coal/sorbent combinations. A 5.5 atm turtine inlet gas pressure and inlet gas temperatures from 700 to 800 C yielded absolute gas velocities at the stator exit of about 500 m/s. The angular rotation speed (40,000 rpm) of the six inch diameter rotors was equivalent to a tip speed of about 300 m/s, and average gas velocities relative to the rotating surface ranged from 260 to 330 m/s at mean radius. The rotor erosion pattern reflects heavy particle separation with severe (5 to 500 cm/yr) erosion at the leading edge, pressure side center, and suction side trailing edge at the tip. The erosion distribution pattern provides a spectrum of erosion/oxidation/deposition as a function of blade position. This spectrum includes enhanced oxidation (10 to 100 x air), mixed oxides in exposed depletion zones, sulfur rich oxides in deposition zones, and rugged areas of erosive oxide removal

N79-31372\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### SURVEY OF ION PLATING SOURCES

Tativaldis Spalvins 1979 25 p refs Presented at 26th Natl. Vacuum Symp., N. Y., 2-5 Oct 1979; sponsored by the Am. Vacuum Soc.

(NASA-TM-79269; E-188) Avail NTIS HC A02/MF A01 CSCL 11F

Based on the type of evaporation source, gaseous media and mode of transport, the following is discussed resistance. electron beam, sputtering, reactive and ion beam evaporation, lonization efficiencies and ion energies in the glow discharge determine the percentage of atoms which are ionized under typical ion plating conditions. The plating flux consists of a small number of energetic ions and a large number of energetic neutrals. The energy distribution ranges from thermal energies up to a maximum energy of the discharge. The various reaction mechanisms which contribute to the exceptionally strong adherence formation of a graded sustrate/coating interface are not fully understood, however the controlling factors are evaluated. The influence of process variables on the nucleation and growth characteristics are illustrated in terms of morphological changes which affect the mechanical and tribological properties of the coating MMM

N79-33306°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### SOME TEM OBSERVATIONS OF AI2O3 SCALES FORMED ON NICIAI ALLOYS

J. Smialek and R. Cibala (Case Western Reserve Univ., Cleveland, Ohio). 1979, 34, p. refs. Presented at Gordon Conf. on Corrosion, New London, N. H., 23-27 Jul., 1979.

(NASA-TM-79259, E-171) Avail NTIS HC A03/MF A01 CSCL

The microstructural development of Al2O3 scales on NiCrAl alloys has been examined by transmission electron microscopy. Voids were observed within grains in scales formed on a pure NiCrAl alloy. Both voids and oxide grains grew measurably with oxidation time at 1100 C. The size and amount of porosity decreased towards the oxide-metal growth interface. The voids resulted from an excess number of oxygen vacancies near the oxideinetal interface. Short-circuit diffusion paths were discussed in reference to current growth stress models for oxide scales. Transient oxidation of pure, Y-doped, and Zr-doped NiCrAl was

also examined. Oriented alpha-(AI, Cr)2O3 and Ni(AI, Cr)2O4 scales often coexisted in layered structures on all three alloys. Close-packed oxygen planes and directions in the corundum and spinel layers were parallel. The close relationship between oxide layers provided a gradual transition from initial transient scales to steady state Al2O3 growth.

A79·10420 \* The hot corrosion of Co-25Cr-10Ni-5Ta-3Ai-0.5Y alloy /S-57/. G. J. Santoro (NASA, Lewis Research Center, Cleveland, Ohio). *Corrosion Science*, vol. 18, 1978, p. 651-677, 29 refs.

A cobalt-base alloy, Co-25Cr-10Ni-5Ta-3Al-0.5Y (S-57), was subjected to hot corrosion in Mach 0.3 burner-rig combustion gases at maximum alloy temperatures of 900 and 1000 C. Various salt concentrations were injected into the burner: 0.5, 2,5, and 10 parts per million synthetic sea salt and 4 parts per million sodium sulfate (Na2SO4). The extent of corrosion was determined by measuring the maximum depth of corrosion in the alloy, and the corrosion process was studied by metallography, X-ray diffraction, scanning electron microscopy, and electron microprobe analysis. While S-57 was found to possess only moderate oxidation resistance at these temperatures, this alloy resisted significant hot corrosion attack under all but the most severe test conditions. The process of hot corrosion attack under the most severe conditions of this study was primarily sulfidation. (Author)

A79-13100 \* # Some properties of !ow-vapor-pressure braze alloys for thermionic converters. V. L. Bair (NASA, Lewis Research Center, Cleveland, Ohio). Institute of Electrical and Electronics Engineers, International Conference on Plasma Science, Monterey, Calif., May 15-18, 1978, Paper. 13 p. 10 refs.

Density, dc electrical resistivity, thermal conductivity, and linear thermal expansion are measured for arc-melted rod-shaped samples of binary eutectics of Zr, Hf, Ru, Nb, Ir, Mo, Ta, Os, Re, and W selected as very-low-pressure braze fillers for thermionic converters. The first two properties are measured at 296 K for Zr-21.7 at% Ru, Zr-13 wt% W, Zr-19 wt% W, Zr-22.3 at% Nb, Nb-66.9 at% Ru, Hf-25.3 wt% Re, Zr-25.7 at% Ta, Hf-22.5 at% W, and Nb-35 wt% Mo. The last property is measured from 293 K to 2/3 melting point for specified alloys of different compositions. Resistivities of 0.000055 to 0.000181 ohm-cm are observed with the alloys having resistivities about ten times that of the less resistive constituent metal and about three times that of the more resistive constituent metal, except for Zr-19 wt% W and Nb-35 wt% Mo (greater resistivities). Thermal expansion coefficients vary from 0.000006 to 0.0000105/K. All brazes exhibit linear thermal expansion near that of their constituent metals.

A79-14955 \* E. Longitudinal shear behavior of several oxide dispersion strengthened alloys. T. K. Glasgow (NASA, Lewis Researth Center, Cleveland, Ohio). American Institute of Mining, wetallurgical and Petroleum Engineers, Fall Meeting, Chicago, Ill., Oct. 24-27, 1977, Paper. 19. p. 11 refs.

Two commercial oxide dispersion strengthened (ODS) alloys, MA-753 and MA-754, and three experimental ODS alloys, MA-757E. MA-755E, and MA-6000E, were tested in shear at 760 C. Comparisons were made with other turbine-blade and vane alloys. All of the ODS alloys exhibited less shear strength than directionally solidified Mar-M 200 + Hf or than conventionally cast B-1900. The strongest ODS alloy tested, MA-755E, was comparable in both shear and tensile strength to the lamellar directionally solidified eutectic alloy gamma/gamma-prime - delta. Substantial improvements in shear resistance were found for all alloys tested when the geometry of the specimen was changed from one generating a transverse tensile stress in the shear area to one generating a transverse compressive stress. Finally, 760-C shear strength as a fraction of tensile strength was found to increase linearly with the log of the transverse tensile ductility. (Author)

A79-16038 \* Interpolation and extrapolation of creep rupture data by the Minimum Commitment Method. I - Focal-point convergence. II - Oblique translation. III - Analysis of multiheats. S. S. Manson (Case Western Reserve University, Cleveland, Ohio) and C. R. Ensign (NASA, Lewis Research Center, Cleveland, Ohio). In: Characterization of materials for service at elevated temperatures; Proceedings of the Pressure Vessel and Pipir.g Conference, Montreal, Canada, June 25-29, 1978. (A79-16026 04-26) New York, American Society of Mechanical Engineers, 1978, p. 299-457. 26 refs. Research supported by the Electric Power Research Institute and NASA.

The framework in which minimum-commitment analyses of creep-rupture data can be implemented is outlined. The approach is termed the focal point convergence method (FPCM) because the basic parameter A, also known as stability factor, is geometrically the (imaginary) focal point of convergence of all isothermals when extended to the very long or very short times necessary for such convergence to occur. The method can be implemented either by manual-graphical analysis or by computer code. The method is illustrated in detail for the nickel-base alloy Astroloy, as well as for steels, other nickel-base alloys, and aluminum alloys. The minimumcommitment concept is extended to the analysis of creep-rupture data where each isothermal is generated by an oblique translation of the 'master curve' when plotted on log rupture time and log stress axes. The oblique translation method uses the same types of functions in the FPCM. Approaches for treating multiheats on the basis of the FPCM are discussed in detail.

A79-19458 An acoustic emission study of plastic deformation in polycrystalline aluminium. R. C. Bill (NASA, Lewis Research Center, Cleveland, Ohio), J. R. Frederick, and D. K. Felbeck (Michigan, University, Ann Arbor, Mich.). *Journal of Materials Science*, vol. 14, Jan. 1979, p. 25-32, 7 refs.

Acoustic emission experiments were performed on polycrystalline and single crystal 99.99% aluminum while undergoing tensile deformation. It was found that acoustic emission counts as a function of grain size showed a maximum value at a particular grain size. Furthermore, the slip area associated with this particular grain size corresponded to the threshold level of detectability of single dislocation slip events. The rate of decline in acoustic emission activity as grain size is increased beyond the peak value suggests that grain boundary associated dislocation sources are giving rise to the bulk of the detected acoustic emissions. (Author)

A79-21299 \* = Effects of compositional changes on the performance of a thermal barrier coating system. S. Stecura (NASA, Lewis Research Center, Cleveland, Ohio). American Ceramic Society, Annual Conference on Composites and Advanced Materials, 3rd. Merritt Island, Fla., Jan. 21-24, 1979, Paper 32 p. 14 rets.

Systems consisting of Ni base bond coatings containing about 16Cr, 6AI, and from 0.15 to 1.08Y (all in wt %) and zirconium oxide layers containing from 4.0 to 24.4Y203 were evaluated for suitability as thermal barrier systems for advanced aircraft gas turbine engine components. The evaluations were performed in a cyclic furnace between 990 and 280 C as well as between 1095 and 280 C on solid specimens, in a natural gas oxygen torching between about 1200 and 100 C on solid specimens and up to 1580 C surface temperatures on air cooled blades, and in a Mach 1.0 burner rig up to 1570 C surface temperatures on air cooled blades. The data indicate that the best systems consist of combin ions involving the Ni 16.4Cr 5.1AI 0.15Y and Ni 17.0Cr 5.4AI 0.3 if bond coatings and the 6.2Y203 and 7.9Y203 (all in wt %) statisfized zirconium oxide livers.

A79.21301\* Shear rupture of a directionally solidified eutectic gamma/gamma prime alpha /Mo/ alloy. F. H. Harf INASA Lewis Research Center Cleveland Office Materials Research Somety Contenence on In Sity Composites III. Boston Mass. Nov. 27 Dec. 1. 1978, Paper 14 p. 8 orb.

Directionally solidified gamma gamma pome, align (Molleuter bif alloys are being evaluated to application as advanced andraft

engine turbine blades. Their excellent high temperature strength is partly due to their directionally aligned microstructure. However, alloys with such directional structures may display low shear strength at 760 C, the perating temperature of advanced blade roots. The objective of this investigation was to determine the shear rupture strength of the gamma/gamma-prime - alpha eutectic alloy and possibly to improve it by microstructural and heat-treatment variations. Bars of gamma/gamma-prime - alpha alloy containing nominally 5.7% Al and 33.5% Mo by weight with balance Ni were directionally solidified at rates between 10 and 100 mm per hour. Materials were solidified in furnaces with thermal gradients at the liquid-solid interface of 250 or 100 C per cm. A limited number of longitudinal shear rupture tests were conducted at 760 C and 207 MPa in the as-solidified and in several heat-treated conditions. It was found that the shear rupture failures are partly transgranular and that resistance to failure is promoted by good fiber alignment and a matrix structure consisting mainly of gamma-prime. Well-aligned as solidified specimens sustained the shear stress for an average of 81 hours, while cellular material failed in one hour or less.

A79-24262 \* Influence of composition, annealing treatment, and texture on the fracture toughness of Ti-5Al-2.5Sn plate at cryogenic temperatures. R. H. Van Stone (GE Corporate Research and Development Center, Schenectady, N.Y.), J. L. Shannon, Jr., W. S. Pierce (NASA, Lewis Research Center, Strength of Materials Section, Cleveland, Ohio), and J. R. Low, Jr. (Carnegie-Mellon University, Pittsburgh, Pa.). In: Toughness and fracture behavior of titanium, Proceedings of the Symposium, Toronto, Canada, May 1-6, 1977. (A79-24256 08-26) Philadelphia, Pa., American Society for Testing and Materials, 1978. p. 154-179. 29 refs. Grant No. NGR-39-087-047.

A79-27233\* A feasibility study of a diffusion barrier between Ni-Cr-Al coatings and nickel-based eutectic alloys. S. G. Young and G. R. Zellars (NASA, Lewis Research Center, Cleveland, Ohio). (International Conference on Metallurgical Coatings, San Francisco, Calif., Apr. 3-7, 1978.) Thin Solid Films, vol. 53, 1978, p. 241-250, 16 refs.

Coating systems have been proposed for potential use on eutectic alloy components in high-temperature gas turbine engines. In a study to prevent the deterioration of such systems by diffusion, a tungsten sheet 25 microns thick was placed between eutectic alloys and an Ni-Cr-Al layer. Layered test specimens were aged at 1100 C for as long as 500 h. Without the tungsten barrier the delta phase of the eutectic deteriorated by diffusion of niobium into the Ni-Cr-Al. Insertion of the tungsten barrier stopped the diffusion of niobium from the delta phase. Chromium diffusion from the Ni-Cr-Al into the gamma/gamma-prime phase of the eutectic was greatly reduced by the barrier. However, the barrier thickness decreased with time, and tungsten diffused into both the Ni-Cr-Al and the eutectic. When the delta platelets were aligned parallel rather than perpendicular to the Ni-Cr-Al layer, diffusion into the eutectic was reduced. (Author)

A79-28276 \* An oxide dispersion strengthened alloy for gas turbine blades. T. K. Glasgow (NASA, Lewis Research Center, Cleveland, Ohio). In: Structures, Structural Dynamics, and Materials Conference, 20th, St. Louis, Mo., April 4-6, 1979, Technical Papers on Dynamics and Loads. (A79-28251 10-39). New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 249-255. 12 refs. (AIAA 79-0763).

The strength of the newly developed alloy MA-6000E is derived from a nickel alloy base, an enlongated grain structure, naturally occurring precipitates of gamma prime, and an artificial distribution of extremely fine, stable oxide particles. Its composition is Ni-15% Ci-2% Mo-2% Ta-4% W-4-5% Al-2-5% Ti-0.15% Zr-0.05% C-0.01% B 1.1% Y2O3. It exhibits strength of a conventional nickel-base alloy at 1400 F, but is quite superior at 2000 F. Its shear strength is relatively low, necessitating consideration of special joining procedures. Its high cycle, low-cycle, and thermal fatigue properties are

excellent. The relationship between alloy micro-structure and properties is discussed. (Author)

A79-32600 \* Effects of thermomechanical processing on strength and toughness of Fe-12Ni reactive metal alloys at 77K. J. R. Stephens and W. R. Witzke (NASA, Lewis Research Center, Cleveland, Ohio). Cryogenics, vol. 19, Mar. 1979, p. 153-160. 10 refs.

A79-34992 \* # Characterization of defect growth structures in ion plated films by scanning electron microscopy. T. Spalvins (NASA, Lewis Research Center, Cleveland, Ohio). American Vacuum Society and American Society for Metals, International Conference on Metallurgical Coatings, San Diego, Calif., Apr. 23-27, 1979, Paper. 10 p. 9 refs.

Gold and copper films (0.2-2 micron thick) are ion plated on very smooth stainless steel 304 and mica surfaces. The deposited films are examined by SEM to identify the morphological growth of defects. Three types of coating defects are distinguished: nodular growth, abnormal or runaway growth, and spits. The potential nucleation sites for defect growth are analyzed to determine the cause of defect formation. It is found that nuclear growth is due to inherent surface microdefects, abnormal or runaway growth is due to external surface inclusions, and spits are due to nonuniform evaporation and ejection of droplets. All these defects have adverse effects on the coatings.

S.D.

A79-34995 \* # Fretting wear of iron, nickel, and titanium under varied environmental conditions. R. C. Bill (NASA, Lewis Research Center; U.S. Army, Aviation Research and Development Command, Cleveland, Ohio). ASME, ASLE, ASM, ASTM, SAE, SME, ACS, AIME, and APS, International Conference on Wear of Materials, Dearborn, Mich., Apr. 16-18, 1979, Paper. 29 p. 21 refs.

Fretting wear experiments were conducted on high-purity iron, nickel and titanium in air under conditions of varied humidity and temperature, and in nitrogen. For iron and titanium, maximum fretting occurred at 10 and 30 percent relative humidity respectively. Nickel showed a minimum in fretting wear at about 10% relative humidity. With increasing temperature, all three metals initially showed reduced fretting wear, with increasing wear observed as temperatures increased beyond 200 300 C. For litanium, dramatically reduced fretting wear was observed at temperatures above 500 C, relatable to a change in oxidation kinetics. All three metals showed much less fretting wear in N2 with the presence of moisture in N2 having a proportionally stronger effect than in air. (Author)

A79-34997 \* \*\* Adherence of sputtered titanium carbides. W. A. Branard and D. R. Wheeler (NASA, Lewis Research Center, Cleveland, Ohio). American Vacuum Society and American Society for Metals, International Conference on Metallurgical Cost ings, San Diego, Calif., Apr. 23-27, 1979, Paper, 8 p. 15 refs.

The study searches for interface treatment that would increase the adhesion of TiC coating to nickel and titanity base alloys, mené 41 (19 wt percent Cr. 11 wt percent Mo, 3 wt percent Timiliance Ni) and Ti-6Al-4V (6 wt percent Al, 4 wt percent V, balance Ti) are considered. Adhesion of the coatings is evaluated in pin-and disk friction tests. The coatings and interface regions are examined by X-ray photoelectron spectroscopy. Results suggest that sputtered refractory compound coatings adhere best when a mixed compound of coating and substrate metals is formed in the interfacial region. The most effective type of refractory compound interface appears to depend on both substrate and coating material. A combination of metallic interlayer deposition and mixed compound interface formation may be more effective for some substrate coating combinations than either alone.

A79-38977 \* # The strainrange partitioning behavior of an advanced gas turbine disk alloy, AF2-1DA. G. R. Halford and A. J. Nachtigall (NASA, Lewis Research Center, Cleveland, Ohio). A/AA, SAE, and ASME. Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, A/AA Paper 79-1192. 10 p. 14 \*s.

The low-cycle, creep-fatigue characteristics of the advanced gas turbine disk alioy, AF2-1DA have been determined at 1400 F and are presented in terms of the method of strainrange partitioning (SRP). The mean stresses which develop in the PC (tensile Plasticity reversed by compressive Creep) and CP (tensile Creep reversed by compressive Plasticity) type SRP cycles at the lowest inelastic strainrange were observed to influence the cyclic lives to a greater extent than the creep effects and hence interfered with a conventional interpretation of the results by SRP. A procedure is proposed for dealing with the mean stress effects on life which is compatible with SRP.

(Author)

A79-39972 \* A proposed physical model for the impregnated tungsten cathode based on Auger surface studies of the Ba-O-W system. R. Forman (NASA, Lewis Research Center, Cleveland, Ohio). Applications of Surface Science, vol. 2, 1979, p. 258-274. 15 refs.

Auger spectra and work function measurements are used to study the surface reactions between tungsten surface and adsorbed layers of barium, and barium and oxygen. The barium on an impregnated tungsten cathod seems to be an intermediate state, probably a coadsorbed barium-oxygen layer on tungsten. A slightly revised version of the previously suggested (1976) impregnated tungsten cathode model is proposed. This revised model assumes that the cathode surface during life has an adsorbed surface layer of a monolayer or less of both barium and oxygen on the surface. At end of life, steep drop in electron emission and resultant cathode failure occur. Recent NASA life test results on TWT type tubes are reported and explained by the proposed model.

S.D.

A79-49531 \* # Transverse and longitudinal tensile properties at 760 C of several oxide dispersion strengthened nickel-base alloys. A. E. Anglin, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Mining, Metallurgical, and Petroleum Engineers, Annual Meeting, 108th, New Orleans. 11, Feb. 18-20, 1939, Paper, 22 p. 8 refs.

The transverse and longitudinal tensile properties of the oxide dispersion strengthened nickel-base alloys were determined at 760 C. The alloys with small amounts of gamma prime have strength levels suitable for turbine vane applications, while other highly alloyed, gamma prime strengthened superalloys have strengths typical of turbine blade materials. These alloys were produced by mechanical alloying and extrusion and the turbine blade alloys were also directionally recrystallized. Resultant grain aspect ratios varied from 1:1 to over 20.1. Longitudinal tensile strengths ranged from 285 to 1175 MPa, while longitudinal elongations were in excess of 4 percent for all alloys. Transverse tensile strengths were comparable to longitudinal strengths, but transverse ductility levels were generally less than 2 percent elongation. Tensile and yield strengths increased with increasing strain rate over the range 0.001 to 0.05 per second. Ductility in both orientations was not strain rate sensitive but could be related to grain size and grain aspect ratio. (Author)

A79-50912 \* Chemically frozen multicomponent boundary layer theory of salt and/or ash deposition rates from combustion gases, D. E. Rosner, B. K. Chen (Yale University, New Haven, Conn.), G. C. Fryburg, and F. J. Kohl (NASA, Lewis Research Center, Cleveland, Ohio). Combustion Science and Technology, vol. 20, no. 3-4, 1979, p. 87-106, 57 refs. Grant No. NsG-3107.

There is increased interest in, and concern about, deposition and corrosion phenomena in combustion systems containing inorganic condensible vapors and particles (salts, ash). To meet the need for a computationally tractable deposition rate theory general enough to embrace multielement/component situations of current and future gas turbine and magnetogasdynamic interest, a multicomponent

chemically 'frozen' boundary layer (CFBL) deposition theory is presented and its applicability to the special case of Na2SO4 deposition from seeded laboratory burner combustion products is demonstrated. The coupled effects of Fick (concentration) diffusion and Soret (thermal) diffusion are included, along with explicit corrections for effects of variable properties and free stream turbulence. The present formulation is sufficiently general to include the transport of particles provided they are small enough to be formally treated as heavy molecules. Quantitative criteria developed to delineate the domain of validity of CFBL-rate theory suggest considerable practical promise for the present framework, which is characterized by relatively modest demands for new input information and computer time (Author)

A79-52697 \* Analysis of solidification interface shape during continuous casting of a slab. R. Siegel (NASA, Lewis Research Center, Cleveland, Ohio). International Journal of Heat and Mass Transfer, vol. 21, Nov. 1978, p. 1421-1430, 11 refs.

An analysis was made of the two-dimensional interface shape of a slab ingot being cast continuously by withdrawing it from a mold. The sides of the ingot are being cooled and the upper boundary of the ingot is in contact with a pool of molten metal. The solidification interface shape was determined from the analysis of the heat flow, utilizing the condition that the solidification interface is at constant temperature and must be normal to the lines of heat flow carrying away latent heat of fusion from the interface. The analysis includes the effect of interface curvature which, for a constant rate of withdrawing the cast ingot from the mold, causes the solidification to be nonuniform along the interface. The analysis was carried out by a conformal mapping procedure (Author)

N79-11180\*# TRW Inc. Cleveland Ohio

EXPLORATORY THERMAL MECHANICAL FATIGUE RE SULTS FOR RENE' 80 IN ULTRAHIGH VACUUM Final Report, 11 Jul. 1977 11 Jul. 1978

A A Sheinker Oct 1978 23 p refs

(Contract NAS3 21019)

NASA CR 159444 TRW ER 80281 Avail NTIS

HC A03/MF A01 CSCL 11F

A limited study was conducted of the use of strainage partitioning for predicting the thermalmechanical fatigue life of cast nickel base superalloy. Rene. 80. The fatigue lives obtained by combined inphase thermal and mechanical strain cycling between 400 C 1752 Fl and 1000 C 11802 Fl in an ultrahigh vacuum were considerably shorter than those represented by the four basic partitioned inelastic strainrange fatigue life relationships established previously for this alloy at 871 C (1600 F) and 1000 C 1:832 F) in an ultrahigh vacuum This behavior was attributed to the drastic decrease in ductility with decreasing temperature for this alloy. These results indicated that the prediction of the thermal mechanical fatique life of Rene 80 by the method of strainrange partioning may be improved if based on the four basic fatigue life relationships determined at a lower temperation in the thermal mechanical strain cycle

Author

N79-12202\*# Carnegie-Mellon Inst of Research, Pittsburgh.

EVALUATION OF THE MECHANICAL PROPERTIES OF ELECTROSLAG REFINED Fe 12Ni ALLOYS

G K Bhat Apr 1978 70 p refs (Contract NAS3-20370)

(NASA CR 159394) Avail NTIS HC A04/MF A01 CSCL 11F

Three Fe 12Ni riloys incividually alloyed with small amounts of V. Ti, and Al. were manufactured through different melting techniques, with special emphasis on electroslag remelting, in order to achieve different levels of metal purity and associated costs. The relative effectiveness of these melting techniques was evaluated from tensile and slow bend fracture toughness behavior at 25 C and 196 C after tempering the test specimens at various temperatures. The best melting procedure was vacuum induction melting (VIM) with or without electroslag remelting (ESR). VIM+ESR is the recommended procedure since ESR provides increased yield of plate product, a reduction of overall manufacturing costs and depending on the alloy composition. improved tensile and fracture toughness properties.

N79-16948\* # General Electric Co., Schenectady, N. Y. Corporate Research and Development Center

EVALUATION OF DIRECTIONALLY SOLIDIFIED EUTECTIC SUPERALLOYS FOR TURBINE BLADE APPLICATIONS Final Report

Michael E. Henry, Melvin R. Jackson, and John L. Walter Apr. 1978 107 p refs

(Contract NAS3-19711)

(NASA-CR-135151: SRD-78-198) Avail NTIS

HC A06/MF A01 CSCL 11F

Alloys from the following systems were selected for property evaluation. (1) gamma/gamma-Mo (Ni-base, rods of Mo); (2) gamma-beta (Ni-base, lamellae or rods of (Ni, Fe/Co Al); and (3) gamma-gamma (Ni-base rods of Ni3Al gamma). The three alloys were subjected to longitudinal and transverse tensile and ruptime tests from 750 C to 1100 C, longitudir il shear strength was measured at several temperatures, resistance to thermal cycling to 1150 C was determined, cyclic oxidation resistance was evaluated at 750 C and 1100 C, and Jach system was directionally solidified in an alumina shell mold turbine shape to evaluate mold/metal reactivity. The gamma/gamma Mo system has good rupture resistance, transverse properties and processability, and is a high potential system for turbine blades. The gamma-beta system has good physical properties and oxidation resistance, and is a potential system for turbine vanes. The gamma-gamma system has good high temperature rupture resistance and requires further exploratory research.

N79-20221\*# Minnesota Univ., Minneapolis. WHISKERS, CONES AND PYRAMIDS CREATED IN SPUTTERING BY ION BOMBARDMENT Final Report

G. K. Wehner Mar 1979 47 p refs (Grant NsG-3041)

(NASA-CR-159549) Avail NTIS HC A03/MF A01 CSCL 11F

A thorough study of the role which foreign atoms play in cone formation during sputtering of metals revealed many experimental facts. Two types of cone formation were distinquished, deposit cones and seed cones. Twenty-six combinations of metals for seed cone formation were tested. The sputtering yield variations with composition for combinations which form seed cones were measured it was demonstrated that whisker growth becomes a common occurrence when low melting point material is sputter deposited on a hot nonsputtered high melting point electrode

N79-20222\*# General Electric Co., Schenectady, N. Y. EVALUATION OF AN ADVANCED DIRECTIONALLY SOLIDIFIED GAMMA GAMMA -ALPHA Mo EUTECTIC ALLOY

M. F. Henry, M. R. Jackson, M. F. X. Gigliotti, and P. B. Nelson. Jan 1979 67 p refs

(Contract NAS3-20383)

(NASA-CR-159416. SRD-78-191) NTIS

HC A04/MF A01 CSCL 11F

An attempt was made to improve on the properties of the candidate jet engine turbine blade material AG-60, a gamma/ gamma prime-alpha Mo eutectic composite. Alloy 38 (AG-170) was evaluated in the greatest detail. This alloy, Ni-5 88 A1-29 74 Mo 1 65 V:1 2C Re (weight percent), represents an improvement beyond AG-60, based on mechanical testing of the transverse and/or longitudinal orientations over a range of temperatures in tension, shear, rupture, and rupture after thermal exposure. It is likely that other alloys in the study represent a similar improve-

N75-24121\*# AiResearch Mfg Co. Phoenix, Ariz LOW-COST DIRECTIONALLY SOLIDIFIED TURBINE BLADES, YOLUME 1 Completion Report

L W Sink, 5 S. Hoppin, III, and M Fujii Jan 1979 272 p. (Contract NAS3-20073)

(NASA-CR 159464, AIF a. arch-21-2953-1) Ava. NTIS HC A12/MF A01 CSCL F

A low cost process or manufacturing high stress rupture strength directionally-solidified high pressure turbine blades was successfully developed for the TFE73:-3 Turbofan Engine The basic processing parameters were established using MAR-M 247 and employing the exothermic directional-solidification process in trial castings of turbine blades. Nickel-based alloys were evaluated as direct onally-solidified cast blades. A new turbine blade, disk, and associated components were then designed using previously determined material propertie. Engine tes siwere run and the results were analyzed and compared to the originally established goals. The results showed that the stress rupture strength of exothermically heated, directionally-solidized MAR-M 247 turbin: blades exceeded program objectives and that the performance and cost reduction goals were achieved RES

N79-25184\*# Yale I liv New Haven, Conn High comperature Chemical Reaction Engineering La',

EXPERIMENTAL STUDIES OF THE FORMATION DEPOSITION OF SCHUM SULFATE IN FROM COMBUS-TION CASES Semiannu: Report, 18 May - 15 Nov. 1978 Daniel E Rosner 15 Nov 1978 16 p refs

(Grant 1.sG-3169)

(NASA-CR-159613, SAR-2) Avail NTIS HC A02/MF A01 CSCL 21B

Interference in a reflected beam of monochromatic light a linearly polarized helium-neon laser was used to determine the dew point and deposition rate of 203 on a heated platinum target Preliminary results at different BCI3 seed levels, except for one flow velocity and equivalence ratio (817) are presented and discussed. Alkali chloride reactions with atomic oxygen. were also investigated Readily detectable Na\*(g) and K\*(g) atoms were observed in emission at 589 nm. 766nm. 796nm. respectively AHH

N79-25196\*# Pitisburgh Univ. Pa Dept of Metallurgical and Materials Engineering

AN INVESTIGATION OF THE INITIATION STAGE OF HOT CORKOSION IN NI-BASE ALLOYS Progress Report

T T Huang and G H Meier 31 Mar 1979 44 p refs (Grant NsG-3214)

INASA CR 15, 3161 Avuil NTIS HC A03 MF A01 CSCL

The mechanisms which lead to the destruction of a normally protective scale during the initial stages of liot corrosion of 14 nickel pase alloys contaminated with Na2SO4 and other cindensed deposits were investigated. A continuous reading microbalance was used to record weight changes at temperatures between 900 C and 1000 C at 1 atmosphere pressure of slowly flowing exygen. The reaction was initiated by raising a preheated furnace around the quartritube in which the specimen was supported with exygen flowing. The furnace was raised in a line period of seconds. At 900 C the system, and specimen came to thermal equilibrium in less than one minute Oxidizad specin is were studied using optical and scanning electron metallography and X-ray diffraction techniques. Transmission electron microscopy and electron diffraction spectroscopy were also used to identify the structure of carbides in some of the commercial alloys ARH

N79-26175\*# Battelle Columbus Labs Ohio Metalworking

COMPUTER AIDED ANALYSIS AND DESIGN OF THE SHAPE ROLLING PROCESS FOR PRODUCING TURBINE ENGINE AIRFOILS Intarim Topical Report, 1 Oct. 1976 31 Dec. 1977

C ft Lahot, N Akgerma, and T Altan, Mar 1978, 65 p.

(Contract NAS3-20380)

(NASA-CR-135367) Avail NTIS HC A04/MF A01 CSCL

Mild steel (AISI 1018) was selected as model cold-rolling material and Ti-6AI-4V and INCONEL 718 were selected as typical hot-rolling and cold rolling alloys, respectively. The flow stress and workability of these alloys were characterized and friction factor at the roll/workpiece interface was determined at their respective working conditions by conducting ring tests. Computer-aided mathematical models for predicting metal flow and stresses, and for simulating the shape-rolling process were developed. These models utilize the upper-bound and the slab methods of analysis, and are capable of predicting the lateral spread, roll-separating force, roll torque and local stresses, strains and strain rates. This computer-aided design (CAD) system is also capable of simulating the actual rolling process and thereby designing roll-pass schedule in rolling of an airfoil or similar shape. The predictions from the CAD system were verified with respect to cold rolling of mild steel plates. The system is being applied to cold and hot isothermal rolling of an airfoil shape, and will be verified with respect to laboratory experiments under controlled conditions Author

N79-32326\*# Pratt and Whitney Aircraft Group, West Palm Beach, His Government Products Div.

#### DEVELOPMENT OF SPUTTERED TECHNIQUES FOR THRUST CHAMBERS Final Report

J R Mullaly and P A Allard Mar 1979 96 p refs (Contract NAS3-20377)

(NASA-CR-159637. FR-11 HC A05/MF A01 CSCL 11F FR-11409) NTIS

The 0.152 cm thick sputtered and copper deposits were electron beam welded to wrought copper Tensile specimens were machined from the weld assemblies and tested at room temperature. Tensile strength approached the strength of wrought material Elongations up to 25% were measured Sputtered

aluminum was used to iill 0 157 cm wide by 0 127 cm deep grooves in thrust chamber spool piece liners. The liners were closed out by sputtering copper from post and hollow cathodes.

N79-33305\*# Westinghouse Astronuclear Lab Pittrourgh, Pa INTERDIFFUSION REHAVIOR OF TUNGSTEN OR RHEN-IUM AND GROUP 5 AND 6 ELEMENTS AND ALLOYS OF THE PERIODIC TABLE. PART 28: APPENDICES Final Report

F G Arcella Sep 1974 261 p refs

(Contract : 3-13231) (NASA-TR- 1525, WANL-M-FR-74-005 Pt-2) Avail NTIS

HC A1 . . . . . . . . CSCL 11F

illowing are appended (1) The Hartley Computer 12' The Lifshin Computer Program, (3) Modification of the Culby Magic Program to Quantitative Electron Microprobe Analysis, and (4) Error and Correction Analysis

### 27 NONMETALLIC MATERIALS

Includes physical, chemical, and mechanical properties of plastics, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials.

N79-11216\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

MODIFICATION OF THE ELECTRICAL AND OPTICAL PROPERTIES OF POLYMERS Patent Application

M J Mirtich and James S Sovey, inventors (to NASA) Filed 7 Nov 1978 11 p

(NASA-Case LEW-13027-1, US-Patent-Appl-SN-958575) Avail NTIS HC A02/MF A01 CSCL 07C

The surface of a polymer is irridiated to modify the optical and electrical properties as well as to change the surface morphology. A polymer is placed in a vacuum of about 4x 10 to the minus 5th power tor. A surface of the polymer is exposed to a beam of argon ions having an energy between 500 and 1000 eV and an ion beam current density between 0.1 and 1.0 mA/sq cm. The resulting texturing of the surface causes a large decrease in spectral transmittance at all wavelengths. The surface conductivity of the polymer is also increased. The textured surface further enhances the adherence of thin films to the polymer. A polymide, (Kaptan) and a fluorinated ethylene propylene, (Tefion) are surface timated in accordance with the invention.

NASA

N79-12223\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

DEVELOPMENT OF SPRAYED CERAMIC SEAL SYSTEMS FOR TURBINE GAS PATH SEALING

Robert C Bill (AVRADCOM Res and Technol Lübs), L T Shembob (Pratt and Whitney Aircraft Group, East Hartford, Conn.), and O L Stewart (Pratt and Whitney Aircraft Group East Hartford, Conn.), 1978–22 p. refs. Presented at the Winter Ann. Meeting, San Francisco, 10.15 Dec. 1978, sponsored by Am. Soc. of Mech. Engr.

(NASA-TM 79022 E-9819 AVRADCOM-TR-78-52) Avail NTIS HC A02/MF A01 CSCL 11A

A ceramic seal system is reported that employs plasma sprayed graded metal/ceramic yttria stabilized zirconium oxide (YSZ). The performance characteristics of several YSZ configurations were determined through rig testing for thermal shock resistance abradability and erosion resistance. Results indicate that this type of sealing system offers the potantial to meet operating requirements of future gas turbine angines. — G.G.

N78-13156\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

LUBRICATION AND FAILURE MECHANISMS OF MOLYB-DENUM DISULFIDE FILMS. 1: EFFECT OF AT-MOSPHERE

Robert L Frisaro Dec 1973 29 p

(NASA-TP-1343 E-9600) Avail NTIS HC AC3/MF A01 CSCL

Friction, wear and viear lives of rubbed molybdenum disulfide (MoS2 films applied to sanded 440C HT steel surfaces were avaluated in moist air, diy air, and dry argon. Optical microscope observations were made as a function of sliding distance to determine the effect of moisture and oxygen on the lubricating and failure mechanisms of MoS2 films. In general, the lubrication process consisted of the formation of a thin, metallic colored, coalesced film of MoS2 that flowed between the surfaces in relative motion. In air failure was due to the transformation of the metallic colored, coalesced films this black, powdery material. Water in the air applianted to accelerate the transformation rate. In argon, no transformation of MoS2 was observed with the microscope, but cracking air \* specifing of \*\* coalesced film occurred and resulted in the gradual definition of the film.

Author

N79-13159\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LUBRICATION AND FAILURE MECHANISMS OF MOLYB-DENUM DISULFIDE FILMS. 2: EFFECT OF SUBSTRATE ROUGHNESS

Robert L Fusaro Dec 1978 30 p refs

(NASA-TP-1379, E-9715) Avail: NTIS HC A03/MF A01 CSCL

An optical microscope was used to study the lubrication and failure mechanisms of rubbed MoS2 films applied to three substrate surface finishes; polished, sanded, and sandblasted as a function of sliding distance. The lubrication mechanism was the plastic flow of thin films of MoS2 between flat plateaus on the rider and on the metallic substrate. If the substrate was rough, flat plateaus were created during run-in and the MoS2 flowed across them. Wear life was extended by increasing surface roughness since valleys in the roughened substrate served as reservoirs for MoS2 and as deposit sites for wear debris. In moist air the failure mechanism was the transformation of metallic colored MoS2 films to a black, powdery material that was found by X-ray diffraction to be alpha iron, MoO3, and possibly FeMoO3. In dry argon the failure mechanism was the gradual depletion of MoS2 from the contact region by transverse flow, and the wear debris on the track at failure was alpha iron, residual MoS2. and possibly FeS

N79-15184\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

EFFECT OF NITROGEN-CONTAINING PLASMA ON ADHERENCE, FRICTION, AND WEAR OF RADIOFREQUENCY-SPUTTERED TITANIUM CARBIDE COATINGS

William A Brainard and Donald R Wheeler Jan 1979 21 prefs

(NASA-TP-1377, E-9681) Avail NTIS HC A02/MF A01 CSCL

Friction and wear experiments on 440C steel surfaces that were if sputtered with titanium carbide when a small percentage of nitrogen was added to the plasma were conducted. Roth X-ray photoelectron spectroscopy and X-ray diffraction were used to analyze the resultant coatings. Results indicate that the small partial pressure of nitrogen (approximately 0.5 percent) markedly improves the adherence, friction, and wear properties when compared with coatings applied to sputter-etched surfaces, oxidized surfaces, or in the presence of a small oxygen partial pressure. The improvements are related to the formation of an interface containing a mixture of the nitrides of titanium and iron, which are harder than their corresponding oxides. A R.H.

N79-15185\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

BOUNDARY LUBRICATION, THERMAL AND OXIDATIVE STABILITY OF A FLUORINATED POLYETHER AND A PERFLUOROPOLYETHER TRIAZINE

William R Jones, Jr and Carl E Snyder, Jr (AFML Ohio) 1979 24 p. refs. Proposed for presentation at Ann. Meeting of the Am. Soc. of Lubrication Engineers, St. Louis, Mo., 30 Apr. - 3 May 1979.

(NASA-TM-79064 E-9879). Avail NTIS HC A02/MF A01 CSCL 11H

Boundary lubricating characteristics, thermal stability, and oxidation-corrosion stability were determined for a fluorinated polyether and a perfluoropolyether triazine. A ball on-disk apparatus, a tensimeter, and oxidation-corrosion apparatus were used. Results were compared to data for a polyphenyl ether and a Ciether. The polyether and triazine yielded bettur boundary lubricating characteristics than either the polyphenyl ether or Ciether. The polyphenyl ether had the greatest thermal stability (44.3° C) while the other fluids had stabilities in the range 389 to 397 C. Oxidation corrosion results indicated the following order of stabilities perfluoropolyether trizine greater than polyphenyl ather greater than Ciether greater than fluorinated polyether.

Author

N79-16186\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF THERMAL AGING ON THE TRISOLOGICAL PROPERTIES OF POLYIMIDE FILMS AND FOLYIMIDE-BONDED GRAPHITE FLUORIDE FILMS

Robert L. Fusaro 1979 32 p. refs. Proposed for presentation at the 34th Ann. Meeting, St. Louis, 30 Apr. - May 1979. Sponsored by the Am. Soc. of Lubrication Engr. (NASA-TM-79045; E-9.79-1). Avail. NTIS. HC A03/MF A01 CSCL 07C.

Weight ioss, adherence, friction and wear of polyimide films and polyimide-bonded graphite fluoride films applied to stainless steel disks and to 30d stainless steel thin foils were studied. The films were exposed at temperatures of 315 D, 345 D, 370 D, or 400 C for 100 hours or more and then evaluated at temperatures of 25 D, 315 D, or 345 C in atmospheres of dry or moist air. Polyimide films were found to be brittle after thermal exposure; but polyimide-bonded graphite fluoride possessed good adherence and gave low friction and wear results. Polyimide-bonded graphite fluoride films appear to be good candidates for solid lubrication applications where long thermal soaks are prevalent.

N79-16984\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

HIGH VELOCITY BURNER RIG OXIDATION AND THERMAL FATIGUE BEHAVIOR OF SI3N4- AND SIC BASE CERAMICS TO 1370 DEG C

William A Sanders and James R Johnston Nov 1978 44 p

(NASA-TM-79040, E-9842). Avail: NTIS: HC A03/MF A01 CSCL 11B

One SiC material and three Si3N4 materials including hot-pressed Si3N4 as a baseline were exposed in a Mach-1-gas-velocity burnering simulating a turbine engine environment. Criteria for the materials selection were potential for gas-turbine usage near-net-shape fabricability, and commercial/domestic availability. Cyclic exposures of test vanes up to 250 cycles (50 hr at temperature) were at leading edge temperatures to 1370. C. Materials and batches were compared as to weight change, surface change, fluorescent penetrant inspection, and thermal fatigue behavior. Hot-pressed Si3N4 survived the test to 1370. C. with slight weight losses. Two types of reaction-sintered Si3N4 displayed high weight gains and considerable weight change variability, with one material exhibiting superior thermal fatigue behavior. A siliconized SiC showed slight weight gains, but contiderable batch variability in thermal fatigue.

N78-20240° Mational Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WIDE-TEMPERATURE-SPECTRUM SELF-LUBRICATING COATINGS PREPARED BY PLASMA SPRAYING

Harold E. Sliney 1979 10 p. refs. Presented at the Intern. Conf. on Met. Coatings, San Diego, Calif., 23-27 Apr. 1979, cosponsored by the Am. Vacuum Soc. and the Am. Soc. for Metals.

(NASA-TM-79113, E-9945) Avail NTIS HC A02/MF A01 CSCL 11H

Self-lubricating, multicomponent coatings, which lubricate over a wide range of operating conditions are described. The coatings were successfully applied by plasma-spraying mixed powders onto superalloy substrates. They were evaluated in friction and wear experiments, and in sliding contact bearing tests. These coatings are wear resistant by virtue of their self lubricating characteristics rather than bacause of extreme hardness, a further benefit is low friction. Experiments with simple pin on disk sliding specimens and oscillating plain cylindrical bearing tests were performed to evaluate the tribological properties of the coatinus It was shown that coatings of nichrome glass and calcium fluoride are self-lubricating from about 500 to 900 C, but give high friction at the lower temperatures. The addition of silver to the coating composition improved the low temperature bearing properties and resulted in coatings which are self-lubricating from cryogenic temperatures to at least 870 C: they are therefore, wide temperature spectrum, self-lubricating compositions

N79-21204\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF OXYGEN-NITROGEN RATIO ON SINTERABILITY OF SIALONS

Alan Arias Apr. 1979 24 p refs

(NASA-TP-1382; E-9814) Avail: NTIS HC A02/MF A01 CSCL 11B

The effect of varying the sintering temperature and the oxygen to nitrogen ratio (0/N) on the sinterability of Sialons of the formula Si2 55Al0.60yN4-0.667y was investigated for y between 0.57 and 1.92 (0/N between 0.157 and 0.706). The Sialons reached maximum density on pressureless sintering for 4 hours at about 1760 C in nitrogen. Optimum sinterability with densities up to about 98 percent of theoretical was attained with negligible X-phase in the 0/N range from about 0.2 to 0.3. On sintering at approximately 1830 C the Sialons decomposed with evolution of silicon and aluminum.

N79-21206\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMAL STRESS ANALYSIS OF CERAMIC GAS-PATH SEAL COMPONENTS FOR AIRCRAFT TURBINES

Francis E. Kennedy and Dert C. Bill. Apr. 1979 22 p. refs.
Prepared in cooper in Army Aviation Res. and Develop.
Command. Clevel

(NASA-TP-1437, ), AVRADCOM-TR-78-42) Avail NTIS HC AO2/MF AO. ,L 11B

Stress and temperature distributions were evaluated numerically for a blade-tip seal system proposed for gas turbine applications. The seal consists of an abradable ceramic layer on metallic backing with intermediate layers between the ceramic layer and metal substrate. The most severe stresses in the seal. as far as failure is concerned, are tensile stresses at the top of the ceramic layer and shear and normal stresses at the layer interfaces. All these stresses reach their maximum values during the deceleration phase of a test engine cycle. A parametric study was carried out to evaluate the influence of various design parameters on these critical stress values. The influences of material properties and geometric parameters of the ceramic. intermediate, and backing layers were investigated. After the parametric study was completed a seal system was designed which incorporated materials with beneficial elastic and thermal properties in each layer of the seal. An analysis of the proposed seal design shows an appreciable decrease in the magnitude of the maximum critical stresses over those obtained with earlier configurations.

N79-23216\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECT OF STERILIZATION IRRADIATION ON FRICTIGA AND WEAR OF ULTRAHIGH-MOLECULAR-WEIGHT POLYETHYLENE

William R. Jones, Jr., William F. Hady, and Aldo Crugnola (Lowell Univ.). May 1979 22 p. refs.

(NASA Order C-8756)

(NASA-TP-1462, E-9697) Avail NTIS HC A02/MF A01 CSCL 07C

The effect of stenlization gamma irradiation on the friction and wear properties of ultrahigh molecular weight polyethylene (LHMWPE) sliding against 316L stanless steel in dry air at 23 C was determined A pin-on-disk apparatus was used. Experimental conditions included a 1-kilogram load, a 0.061- to 0.27-meter-per-second sliding valocity, and a 32000- to 578000-meter sliding distance. Although sterilization doses of 2.5 and 5.0 megarads greatly altered the average molecular weight and the molecular weight distribution, the friction and wear properties of the polymer were not significantly changed.

Author

N79-24154\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ION BEAM SPUTTER DEPOSITION OF FLUOROPOLYMERS
Patent Application

Bruce A. Banks and James S. Sovey, inventors (to NASA). Filed 21 May 1979. 8 p.

(NASA-Case-LEW-13122-1; US-Patent-Appl-SN-041146) Avail NTIS HC A02/MF A01 CSCL 07C

ions are impinged on a fluoropolymer target which is the sputter deposition source for a large area substrate to be coated. A clear hydrophobic coating is produced on a substrate of selected solid materials.

N79-27306\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### ADHESIVE MATERIAL TRANSFER IN THE EROSION OF AN ALUMINUM ALLOY

Joshua Salik and William A Brainard May 1979 10 p refs (NASA-TM-79165, E-028) Avail NTIS HC A02/MF A01 CSCL 11A

In order to study the basic mechanisms of arosion, hardened steel balts were shot into annealed 6061 Al alloy targets at velocity of up to 150 m/sec. The projectiles were collected and examined by a scanning electron microscope combined with energy-dispersive X-ray analyzer and it was found that target material in substantial amounts is adhesively transferred to the projectile. The transferred material forms on the projectile surface a layer the thickness of which increases with increases in impact velocity.

N79-27308\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

# AUGER SPECTROSCOPY ANALYSIS OF LUBRICATION WITH ZINC DIALKYLDITHIOPHOSPHATE OF SEVERAL METAL COMBINATIONS IN SLIDING CONTACT

Donald H Buckley Jul 1979 19 p

(NASA-TP-1489, E-9909) Avail NTIS HC A02/MF A01 CSCL

Sliding friction experiments were conducted with aluminum and other riders rubbing on disks of various elemental metals in the presence of a thin film of zinc dialkylidithiophosphate (ZDP). Auger emission spectroscopy was used to in situ monitor the changes in surface chemistry with rubbing under various loads. The metal disks examined included iron, titanium, rhodium, tungsten, molybdenum, and copper. For equivalent films of ZDP, the film is a more effective lubricant for some metals than it is for others. The important active element in the compound varies with the metal lubricated and is a function of metal chemistry. The zinc in the ZDP is susceptible to slectron beam induced desorption.

N79-27309\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

### MODULES OF RUPTURE AND OXIDATION RESISTANCE OF \$12.55AID.600.72N3.52 SIALON

Alan Arias Jul 1979 15 p refs

INASA TP 1490 E 99711 Avail NTIS HC A02/MF A01 CSCL 118

A Sialon of formula Si2 55Al0 600 72N3 52 was made from ball milled alpha Si3N4. AIN, and Si02 by sintering the powder compacts at 1760 C for 4 hours in stagnant nitrogen. This Sialon had an average modulus of rupture ranging from 404 inegapascals (58.6 ksi) at room temperature to 254 megapascals (36.8 ksi) at 1400 C. Oxidation tests at 1400 C in air showed it to have a parabolic oxidation rate constant less than or equal to 2.8x10 to the -10th power sq./cm4 hr, which is similler than that of any other Si3N4 base ceramic reported in the literature.

N79-28307° National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

# CATALYTIC TRIMERIZATION OF AROMATIC NITRILES AND TRIARYL-S-TRIAZINE RING CROSS-LINKED HIGH TEMPERATURE RESISTANT POLYMERS AND COPOLYMERS MADE THEREBY Patent

Li-Chen Hsu, inverior (to NASA) Issued 26 Jun 1979 30 p Filed 12 May 197 Supersedes N77-32244 (15 - 23, p 3049) Division of US Patent Appl. SN-513613, filed 10 Oct 1974, US-Patent-4 061.856

(NASA-Case-LEW-12053-2, US-Patent-4,159,262,

US-Patent-Appl-SN-796263, US-Patent-Class-528-126.

US-Patent-Class-260-37N, US-Patrent-Class-260-42.

US-Patent-Class-260-53. US-Patent-Class-544-193.

US-Patent-Class-528-221, US-Patent-Class-528-223

US-Patent-Class-528-229. US-Patent-Class-528-227 US-Patent-Class-528-225. US-Patent-Class-528-127

US-Patent-Class-528-128, US-Patent-Class-528-127,

US-Patent-Class-528-337. US-Patent-Class-528-338.

US-Patent-Class-528-337. US-Patent Class-528-331. Avail US

Patent and Trademark Office CSCL 07C

Triazine compounds and cross-linked polymer compositions are made by heating aromatic nitriles to a temperature in the range of from about 100 C to about 700 C, and preferably in the range of from about 200 C to about 350 C, in the presence of a catalyst or mixture of catalysts selected from one or more of the following groups (1) organic sulfonic and sulfinic acids. (2) organic phosphonic and phosphinic acids and (3)metallic acetylacetonates, at a pressure in the range of from about atmospheric pressure to about 10,000 psi and preferably in the range of from about 200 psi to about 750 psi Aromatic nitrile-modified (terminated and/or appended) imide, benzimidazole, imidazopyrrolone, quinoxaline, and other condensation type prepolymers or their precopolymers are made which are trimerized with or without a filler by the aforementioned catalytic trimerization process into triary's triazine ring containing or cross-linked polymeric or copolymeric products useful in applications requiring high thermal-oxidative stability and high performance structural properties at elevated temperatures

Official Gazette of the U.S. Patent and Trademark Office

N79-29327\*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

### PLAS...A. SPRAYED COATINGS FOR LUBRICATION OF A TITANIUM ALLOY IN AIR AT 430 deg C

Harold E. Sliney and Donald H. Wisander, Jul. 1979, 14 p. (NASA-TP-1509, E-9876). Avail. NTIS. HC. A02/MF, A01, CSCL 11H.

Plasma sprayed coatings of pure silver and of composite materials containing silver were investigated as possible self lubricating coatings for titanium alloys in air at 430 C. Pure silver provided low friction but was prone to severe plastic deformation and excessive transfer except in coating thicknesses of 0.02 mm or less Additions of nichrome calcium fluoride, and glass to silver were all beneficial in reducing plastic deformation and otherwise improving the coatings. The longest coating wear life, low wear of Ti alloy pilis in sliding contact with the coatings, and a steady friction coefficient of 0.19 were obtained with a four component coating of 0.17 mm thickness. The coating composition, in weight percent is 30 nichrome-30 Ag-25 CaF2-15 glass.

N79-29329\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

#### INFRARED ANALYSIS OF POLYETHYLENE WEAR SPECI-MENS USING ATTENUATED TOTAL REFLECTION SPEC-TROSCOPY

William R Jones and James L Lauer (Rensselaer Polytech Inst.) Jul. 1979 12 p. refs

(NASA-TM-79228 E 130) Avail NTIS HC A02/MF A01 CSCL

Altenuated total reflection infrared spectroscopy was used to analyze ultrahigh molecular weight polyethylene wear test specimens. Three different specimens were analyzed. One specimen was gamma irradiated to a dose of 5.0 MRad, another to a dose of 2.5 MRad, and the final specimen was unirradiated.

There was no conclusive evidence of chemical changes (i.e., unsaturation or oxidation) in the surface regions of any of the polyethylene samples. Therefore, it was concluded that the gamma irradiation sterilization procedure should not after the boundary lubricating properties of the polyethylene.

Author

N79-30378\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

#### STATE-OF-THE-ART OF SIAION MATERIALS

Sunil Dutta 1979 22 p refs Presented at 49th Meeting of the Structures and Materials Panel Including a Specialist Meeting on Ceramics for Turbine Engine Applications, Culogne Germany, 7-12 Oct. 1979 sponsored by AGARD

(NASA-TM-79207: E-092) Avail NTIS HC A02/MF AC1 CSCL

Research presented includes work on phase relations, crystal structure, synthesis, fabrication, and properties of various SiAIONs. The essential features of compositions, fabrication methods, and microstructure are reviewed. High temperature flexure strength, creep, fracture toughness, oxidation, and thermal shock resistance are discussed. These data are compared to those for some currently produced silicon nitride ceramics to assess the potential. SiAION materials for use in advanced gas turbine engines.

N79-30379\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### BEND STRENGTHS OF REACTION BONDED SILICON NITRIDE PREPARED FROM DRY ATTRITION MILLED SILICON POWDER

T P Herbell and T K Glasgow 1979 14 p refs Presented at 3d Ann. Conf. on Composites and Advan Mater. Merritt Island, Fla. 21-24 Jan. 1979, sponsored by Am. Ceram Soc. (Contract EC-77-A-31-1040).

(NASA-TM-79230 E-132 DOE/NASA/1040-79/8) Avail NTIS HC A02/MF A01 CSCL 11G

Dry attrition milled silicon powder was compacted, sintered in helium, and reaction bonded in hitrogen 4 volume percent hydrogen. Bend strengths of bars with as-nitrided surfaces averaged as high as 210 MPa at room temperature and 220 MPa at 1400 C. Bars prepared from the milled powder were stronger than those prepared from as-received powder at both room temperature and at 1400 C. Room temperature strength decreased with increased milling time and 1400 C strength increased with increased milling time.

Author

N79-30380° 

National Aeronautics and Space Administration

Lewis Research Center Cleveland Ohio

#### ANISOTROPIC FRICTION, DEFORMATION, AND FRAC-TURE OF SINGLE-CR'STAL SILICON CARBIDE AT ROOM TEMPERATURE

Kazuhisa Miyoshi and Donald H Buckley Aug 1979 24 piefs

(NASA-TP-1525 E-9988) Avail NTIS HC A02/MF A01 CSCL 07D

Anisotropic friction deformation and fracture studies were conducted with 0001 10 10 and 11(-2)0, silicon carbide surfaces in sliding contact with diamond. The experiments were conducted with loads of 0.1.0.2 and 0.3.N at a sliding velocity of 3 mm/min in mineral oil or in dry argon at room temperature The 1010 direction on the basal 0001 plane exhibits the lowest coefficient of friction and the greatest resistance to abrasion for silicon carbide Anisotropic friction and deformation of the /0001/ /10(-1)0/ and -11(-2)0, silicon carbide surfaces are primarily controlled by the slip system /10(1)0/ 11(-2)0 -The anison pic fractive during sliding on the basal plane is due to surface cracking along 10/1107 and subsurface cracking along 0001. The fracture during sliding on the 111-210 or 10(-1)C, surfaces is due to surface cracking along (0001/ and [11/210] or . 10/1/1 and to subsurface cracking along 10(1)0 Author

N79-30381\*# National Aeronautics and Space Administration Lewis Res. arch. Center, Cleveland, Ohio.

#### LUBRICATING AND WEAR MECHANISMS FOR A HEMI-SPHERE SLIDING ON POLYIMIDE BONDED GRAPHITE FLUORIDE FILM

Robert L. Fusaro Aug 1979 30 p refs

(NASA-TP-1524, E-9965) Avail NTIS HC A03/MF A01 CSCL

Friction, wear life, rider wear, and film wear for a 440 C high-temperature-stainless-steel, hemispherically tipped rider sliding against polyimide-bonded graphite fluoride films were evaluated in a moist-air atmosphere at 25 C. Optical in croscope and surface profilometry observations were made at various sliding intervals to determine how film thickness affected the lubricating and failure mechanisms of the films. Two lubr lation regimes operated for the same load. In the first, the film supported the load and the lubricating mechanism consisted of the shear (plastic flow) of a thin layer of the lubricant between the metallic rider and the film surface in the second, the film did not support the load lit was worn away) and the lubacating mechanism consisted of the shear of very thin lubricant films between flat areas generated on the rider and on sandblasted metallic asperities in the film wear track. Lubricant was supplied from the valleys between the asperities or from the sides of the wear track. With thicker films, wear life increased since a greater lubricant supply was available from the sides of the wear track Author

N79-31391\*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

#### MECHANICAL AND CHEMICAL EFFECTS OF ION-TEXTURING BIOMEDICAL POLYMERS

A J Weigand and M A Cenkus 1979 29 p refs Presented at 32nd Ann Conf of Engr in Med and Biol , Denver 6-10 Oct 1979, sponsored by Alliance for Engr in Med

(NASA:TM:79245; E-152) Avail NTIS HC A03/MF A01 CSCL

To determine whether sputter etching may provide substantial polymer surface texturing with insignificant changes in chemical and mechanical properties, an 8 cm beam diameter, electron bombardment, argon ion source war used to sputter etch lion-texture process) nine biomedical polymers. The materials included silicone rubber. 32% carbon impregnated polyolefin, polyoxymethylene, polytetrafluoroethylene, ultrahigh molecular weight (UHMW) polyethylene UHMW polyethylene with carbon fibers (10%), and several polyureinanes (bioelectric segmented, and cross linked) Ion textured microtensile specimens of each material except UHMW polyethylene and UHMW polyethylene with 10% carbon fibers viere used to determine the effect of ion texturing on tensile properties. Scanning electron microscopy was used to determine surface morphology changes and electron spectroscopy for chemical analysis was used to analyze the near surface chemical changes that result from ion texturing Ion energies of 500 eV with beam current densities ranging from 0.08 to 0.19 mA/sq cm were used to ion texture the various materials. Standard microtensile specimens of seven polymers were exposed to a saline environment for 24 hours prior to and during the tensile testing. The surface chemical changes resulting from sputter etching are minimal in spite of the often significant changes in the surface morphology AWH

N79-32369\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

#### EVALUATION AND AUGER ANALYSIS OF A ZINC DIALKYL-DITHIOPHOSPHATE ANTIWEAR ADDITIVE IN SEVERAL DIESTER LUBRICANTS

William A Brainard and John Ferrante Washington Oct 1979 16 p. refs.

(NASA TP 15¢4 F-9944) Avail NTIS HC A02/MF A01 CSCL 11H

The wear of pure iron in sliding contact with hardened M 2 tool steel was measured for a series of synthetic diester fluids both with and without a zinc dialkyl dithiophosphate (ZDP) antiwear additive as test lubricants. Selected wear scars were analyzed by an Auger emission spectroscopy (AES) depth profiling technique in order to assess the surface film elemental compositions.

tion. The ZDP was an effective antiwear additive for all the diesters except dibutyl oxalate and dibutyl sebacate. The high wear measured for the additive-containing oxalate was related to corrosion, the higher wear measured for the additive-containing sebacate was due to an oxygen interaction. The AES of dibutyl sebacate surfaces run in dry air and in dry nitrogen showed large differences only in the amount of oxygen present. The AES of worn surfaces where the additive was effective showed no zinc, only a little phosphorus, and large amounts of sulfur.

Autho

N79-33325\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PLASMA-SPRAYED ZIRCONIA GAS PATH SEAL TECHNOLOGY: A STATE-OF-THE-ART REVIEW

Robert C Bill 1979 17 p refs Presented at the Manufacturing Technol Advisory Rev. Phoenix, Ariz. 21-25 Oct. 1979: sponsored by the Soc. of Manufacturing Engr. (NASA-TM-79273: AVRADCOM-TR-79-47; E-9941) Avail:

NTIS HC A02/MF A01 CSCL 11A

The benefits derived from application of ceramic materials to high pressure turbine gas path seal components are described and the developmental backgrounds of various approaches are reviewed. The most fully developed approaches are those employing plasma sprayed zirconium oxide as the ceramic material. Prevention of cracking and spalling of the zirconium oxide under cyclic thermal shock conditions imposed by the engine operating cycle is the most immediate problem to be solved before implementation is undertaken. Three promising approaches to improving cyclic thermal shock resistance are described and comparative rig performance of each are reviewed. Advanced concepts showing potential for performance improvements are described.

A K L.

A79-11548 \* Effects of pressure and temperature on hot pressing a sialon. H. C. Yeh and W. J. Waters (NASA, Lewis Research Center, Cleveland, Ohio). American Ceramic Society, Fall Meeting, Hyannis, Mass., Sept. 25-28, 1977, Paper, 17 p. 10 refs.

The combined effects of temperature and pressure on the resulting density of a sialon (i.e., a ceramic composed of Si, Al, Q, and N) are evaluated. Pressures in the 3.5-27.5 MPa range and temperatures in the 1550-1750 C range are considered. It is found that (11 fully dense sialon bodies may be produced at lower temperatures than those usually used in the field, (2) the phase equilibrium reaction is increased by increased pressure, (3) the iso-density contour may be used to help design the desired microstructure, (4) phase changes occurring in the sample during hot pressing influenced sialon densification to a large extent, and (5) microstructures exceeding 98% theoretical density suggest that plastic deformation has contributed to densification. S.C.S.

A79:15534 • Effects of hydrothermal exposure on a low-temperature cured epoxy R W. Lauver (NASA, Lewis Research Center, Cleveland, Ohio) In Reinforced Plastics Composites Institute, Annual Conference, 33rd, Washington, D.C., February 7 10, 1978. Proceedings. (A79:15526:04:24) New York, Society of the Plastics Industry, Inc., 1978, p. 15-C-1 to 15-C-4.

Thermal mechanical analysis was employed to monitor the penetration temperature of a low-temperature epoxy resin (EPON 826 D230). Both neat resin and Eiglass composite samples were examined. The effects of core temperature variation and moisture content on the apparent glass transition temperature were determined.

A79-16659.\* A comparison of the lubricating mechanisms of graphite fluoride and molybdenum disulfide films. R. L. Fusaro (NASA Lewis Research Center, Cleveland, Ohro). In International Conference on Solid Lubrication, 2nd, Denver, Colis August 15.18, 1978. Proceedings. (A79-1665).04.271. Fairk Rubp, III., American Society of Lubrication Engineers, 1978. p. 59.78..21.ces.

A microscopic study of 440 C steel stiding suitably admiraten by

graphite fluoride or molybdenum disulfide solid lubricant lubbed films was conducted. The sliding sur aces, along with the friction, wear, and wear life were observed as a function of the number of sliding revolutions in three different atm. wheres: moist air (10,000 ppm H2O), dry air (less than 20 ppm H2O), or dry argon (less than 20 ppm H2O). In general, the lubricating mechanisms of the two hold lubricants were found to be relatively similar; that is, a dynamic, thin, layer-like film (which sheared on relative motion) was formed between the two metallic surfaces. The mechanisms of failure were found to be somewhat different, however. Failure of MoS2 films was very dependent on atmospheric degradation, while that of graphite fluoride films was more dependent on flow of the lubricant film out of the contact zone. (Author)

A79-16666 \* The friction and wear properties of sputtered hard refractory compounds. W. A. Brainard (NASA, Lewis Research Cenier, Cleveland, Ohio). In: International Conference on Solid Lubication, 2nd, Denver, Colo., August 15-18, 1978, Proceedings. (A75-16651-04-27) Park Ridge, Ill., American Society of Lubrication Engineers, 1978, p. 139-147, 17 refs.

The friction and wear properties of several refractory silicides, boride, and carbide coatings were examined. The coatings were applied to type 4400 steel surfaces by radio-frequency sputtering. The friction and year properties of the coatings were found to be related to stoichiometry and impurity content of the bulk coating as well as the degree of interfacial adherence between coating and substrate. Bulk coating stoichiometry could to large extent be controlled by the application of a negative bias voltage during deposition. Adherence was promoted by the formation of an oxidized layer at the interface. Delibe are preoxidizing of the 4400 produced enhanced adherence for many compounds which is related to the formation of a mixed oxide transition region. (Author)

A79-21022 An XPS study of the adherence of refractory carbide, illicide, and borids RF-sputtered wear-resistant coatings. W. A. Brair and and D. R. Wheeler (NASA, Lewis Research Center, Clevelan J. Ohio). Journal of Vacuum Science and Technology, vol. 15. New Dec. 1978 in 1800-1505. 15 refs.

Radio frequency sputtering was used to deposit refractory carbid., silicide, and beride coatings on 440-C steel substrates. Both sputter etched and pre-oxidized substrates were used and the films were deposited with and without a substrate bias. The composition of the coatings was determined as a function of depth by X-ray photoelectron spectroscopy combined with argun ion etching. Friction and wear tests were conducted to evaluate coating adherence. In the interfacial region there was evidence that bias may produce a graded interface for some compounds. Biasing, while generally improving bulk film stoichiornetry, can adversely affect adherence by removing interfacial oxide layers. Oxides of all film constituents except carbon and iron were present in an cases but the iron axide coverage was only complete on the preoxidized substrates. The film and iron ox des were mixed in the MoSi2 and Mo2C films but layered in the Mo2B5 films. In the case of mixed oxides, preoxidation enhanced film adherence. In the layered case it did not (Author)

A79-21295 NASA thermal barrier coating: Summary and update. F. S. Stepka. (NASA, Lewis Research Center, Turbine Cooling Section, Cleveland, Ohiol. U.S. Navy and U.S. Air Force, Workshop on Cooling Problems in Aircraft Gas Turbines, Monterey, Calif. Sept. 27, 28, 1978. Paper. 22 p. 25 refs. Project SQUID.

The work conducted at the NASA Lewis Besearch Center to evolve and evaluate a thermal barrier coating system will be discussed. A durable, two-layer, plasma-sprayed coating consisting of a ceramic layer over a metallic layer was developed that has the potential of insulating hot engine parts and thereby reducing metal temperatures and coolant flow requirements and or permitting use of less costly and complex cooling configurations and materials. The open summarives the results of analytical and experimental investigations of the coatings on flat metal specimens, turbine vanes and

blades, and combustor liners. Discussed are results of investigations to determine coating adherence and durability, coating thermal, strength and fatigue properties, and chemical reactions of the coating with oxides and sulfates. Also presented are the effect of the coating on aerodynamic performance of a turbine vane, measured vane and combustor liner temperatures with and without the coating, and predicted turbine metal temperatures and coolant flow reductions potentially possible with the coating. Included also are summaries of some current research related to the coating and potential applications for the coating. (Author)

A79-21297 \* # Some properties of an advanced boron fiber.

D. R. Behrendt (NASA, Lewis Research Center, Cleveland, Ohio).

American Ceramic Society, Annual Conference on Composites and Advanced Materials, 3rd, Merritt Island, Fla., Jan. 21-24, 1979, Paper 10 p.

An advanced coreless boron fiber has exhibited tensile strengths which are more than twice that of the normal CVD B/W fibers. The coreless fiber is made by the chemical removal of the tungsten boride core exposed by splitting the as-grown fiber. The easily splittable fiber is made by the chemical vapor deposition of boron on a larger than usual tungsten substrate. It is expected that the ease of splitting is related to residual stresses in these fibers. Measurements of the axial residual stresses in both the normal and the splittable fibers are presented and the results compared. Differences in these stresses are discussed in connection with the ease of splitting in the splittable fibers. (Author)

A79-27231\* Emittance and absorptance of the National Aeronautics and Space Administration ceramic therms' barrie. coating. C. H. Liebert (NASA, Lewis Research Center, Cleveland, Ohio). (International Conference on Metallurgical Coatings, San Francisco, Calif., Apr. 3-7, 1978.) Thin Solid Films, vol. 53, 1978, p. 235-240. 9 refs.

The spectral emittance of a NASA developed zirconia ceramic thermal barrier coating system, consisting of a metal substrate, a layer of Ni-Cr-Al-Y band material and a layer of yttria-stabilized zirconia ceramic material, is analyzed. The emittance, needed for evaluation of radiant heat loads on cooled coated gas turbine components, was measured over a range of temperatures that would be typical of its use on such components. Emittance data were obtained with a spectrometer, a reflectometer and a radiation pyrometer at a single bond coating thickness of 0.010 cm and at a ceramic coating thickness of 0.0.076 cm. The data were transformed into the hemispherical total emittance and were correlated to the ceramic coating thickness and temperature using inultiple-regression curve fitting techniques. The system was found to be highly reflective, and, consequently, capable of significantly reducing radiation heat loads on cooled gas turbine engine components. A.A.

A79-31041 \* Stability of PMR-polyimide monomer solutions. R. W. Lauver, R. D. Vannucci (NASA, Lewis Research Center, Cleveland, Ohio), and W. B. Alston (NASA, Lewis Research Center; U.S. Army, Air Mobility Research and Development Laboratory, Cleveland, Ohio). In: Reinforcing the future, Proceedings of the Thirty-fourth Annual Conference, New Orleans, La., January 30-February 2, 1979, (A79-31026-12-24). New York, Society of the Plastics Industry, Inc., 1979, p. 23-A-1 to 23-A-7, 7 refs.

The stability of alcohol solutions of norbornenyl capped PMR polyimide resins (both PMR-15 and PMR-II) has been monitored during storage at ambient and subambient (5 C and 18 C) temperatures. PMR-15 solutions exhibit nominally two weeks of iseful life and PMR-II solutions, which nominally two days of useful life at ambient conditions. The limiting factor is precipitation of imide reaction products from the monomer solutions. Both solutions exhibit substantially longer useful lifetimes in subambient storage. PMR-15 shows no precipitation after several months storage at subambient temperatures. PMR-II solutions do exhibit precipitates after extended subambient storage (nominally three months at 18

 C), however, the precipitates formed under these conditions can be redissolved. The chemical implications of these observations are discussed.

A79-31249 Mechanisms of graphite fluoride /CFx/n lubrication. R. L. Fusaro (NASA, Lewis Research Center, Cleveland, Ohio). Wear, vol. 53, Apr. 1979, p. 303-323. 10 refs.

Friction, wear and wear life results were compared with optical microscope observations as a function of sliding distance for graphite fluoride rubbed films applied to three surface finishes - polished. sanded and sandblasted. The lubricating process consisted of the plastic flow of thin films of graphite fluoride between flat areas on the rider and on the metallic substrate. If the substrate was rough, flat areas were created during run-in, and the graphite fluoride (CFx)n flowed across them. Wear life was enhanced by restricting radial (or transverse) flow of the graphite fluoride from the contact region by increasing surface roughness. Valleys in the roughened substrate surface served as a reservoir for graphite fluoride and as a deposit site for wear debris. Failure resulted from the gradual depietion of graphite fluoride from the contact region with the subsequent formation of powdery metallic debris that covered both rider and disk surfaces. (Author)

A79-32149 • Friction and fracture of single-crystal silicon carbide in contact with itself and titanium. K. Miyoshi (NASA, Lewis Research Center, Cleveland, Ohio; Kanazawa University, Kanazawa, Japan) and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio). ASLE Transactions, vol. 22, Apr. 1979, p. 146-153, 12 refs.

An investigation was conducted to examine the friction properties and mechanical behavior of single-crystal silicon carbide (0001) surface sliding against itself and against polycrystalline titanium. The results indicate hexagon-shaped pits of silicon carbide and the formation of platelet hexagon-shaped wear debris of silicon carbide due to cleavages of both prismatic and basal planes as a result of silicon carbide sliding against itself. The fracturing of silicon carbide also occurs near the adhesive bond to titanium. The wear debris produced by brittle fracture plows the titanium and transfers to it. Further, the silicon carbide wear debris, which adhered and transferred to titanium, plows the silicon carbide surface and transfers back to it. (Author)

A79-32931 \* Consolidation of Si3N4 by hot isostatic pressing. H. C. Yeh (Cleveland State University, Cleveland, Ohio) and P. F. Sikora (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society Pulletin*, vol. 58. Apr. 1979, p. 444-447, 7 refs. NASA-supported research.

Silicon nitride (Si3N4) is being considered for gas turbine engine applications because present-day metallic alloys are rapidly approaching the limits of their temperature capabilities. The present investigation was undertaken to determine the feasibility of producing a sound, dense Si3N4 body without additives, using conventional gas hot-isostatic-pressing techniques and an uncommon hydraulic hot-isostatic-pressing technique. These two hot-isostatic-pressing (HIP) techniques produce much higher pressure (275-413 MN/sq m) than conventional hot-pressing techniques and have the potential of producing large bodies of desirable shapes. Evaluation was based on density measurement, microscopic examination, both optical and electron, and X-ray diffraction analysis. (Author)

A79-34996 \* Tests of NASA ceramic thermal barrier coating for gas turbine engines. C. H. Liebert (NASA Lewis Research Center Cleveland, Ohio). American Vaccium Society and American Society for Metals, International Conterence on Metallurgical Coatings, Sin Diego, Calit., Apr. 23-27, 1979, Paper, 8 p. 50-ets.

A NASA ceramic thermal barrier coating (TBC) system was tested by industrial and governmental organizations for a variety of aeronautical marine, and ground-based gas turbine eligine amplications. This TBC is a two-layer system with a bond coating of nickel-chromium-aluminum-yttrium (Ni-16Cr-6AI-0.6Y, in wt %) and a ceramic coating of yttria stabilized zirconia (ZrO2-12Y2O3, in wt %). Tests (Liebert and Stenka, 1979) have been conducted to determine corrosion resistance, thermal protection, durability, thermal conductivity, and fatigue characteristics. The information presented covers some of the significant test results obtained on the first three items. The information also includes photographs of coated parts after tests, measurements of coating loss, amount of metal wall temperature reduction when the TBC is used, and extent of base metal corrosion. (Author)

# N79-12238\* Martin Marietta Corp., Denver, Colo. CRYOGENIC PROPELLANT DENSIFICATION STUDY Final Report, Jul. 1977 - Jul. 1978

R O Ewart and R H Dergance Nov 1978 178 p refs

(Contract NAS3-21014)

(NASA-CR-159438 MCR-78-586)

Avail NTIS

HC A09/MF A01 CSCL 211

Ground and vehicle system requirements are evaluated for the use of densified cryogenic propellants in advanced space transportation systems. Propellants rtudied were slush and triple point liquid hydrogen, triple point liquid oxygen, and slush and triple point liquid methane. Areas of study included propellant production, storage, transfer, vehicle loading and system requirements definition. A savings of approximately 8.2 x 100,000 Kg can be achieved in single stage to orbit gross liftoff weight for a payload of 29,484 Kg by utilizing densified cryogens in place of normal boiling point propellants.

G.G.

N79-18053\*# TRW Defense and Space Systems Group Redondo Beach, Calif Chemistry and Chemical Engineering Lab SYNTHESIS OF IMPROVED MOISTURE RESISTANT POLYMERS Final Report, 24 Jun. 1977 - 24 Aug. 1978 M. K. Orell 15 Mar 1979 45 p. refs

(Contract NAS3-21011)

(NASA-CR-159456, TRW-31781-6016-RU-00) Avail NTIS HC A03 MF A01 CSCL 11C

The use of difluoromaleimide-capped prepolymers to provide improved moisture resistant polymers was investigated. Six different prepolymer formulations were prepared by two different methods. One method utilized the PMR approach to polyimides and the second method employed the normal condensation route to provide fully imidized prepolymers. Polymer specimens cured at 450 F exhibited adequate long-term stability in air at 400 F. Moisture absorption studies were conducted on one polymer formulation. Near Polymer specimens exhibited weight gains of up to 2% [w] w], after exposure to 100% relative humidity at 344K (160 F) for 400 hours.

Ni -23218\*# United Technologies Research Center, East Hanlord, Conn

### SYNTHESIS OF IMPROVED MOISTURE RESISTANT POLYMERS Final Report

D A Scola and R H Pater 20 Dec 1978 105 p refs (Contract NAS3-21010)

(NASA-CR-159510, R78-912941-15) Avail NTIS HC A06/MF A01 CSCL 07C

The synthesis and characterization of novel moisture resistant aliphatic polyrimides are described. Several novel aliphatic imides of diversified functionalities were synthesized purified and characterized, they include (1) N-(12-aminododecyl)-5-norbornene-2,3-dicarboximide. (2) N,N'-[[2.2.2-tirifluoro-1-(tirifluoromethyl)ethylidene]] bis [(1.3-dioxo-5.2-iosoindolinedyl) dodecamethylene]] di-5-norbornene-2,3-dicarboximide. (3) N,N'-dodecamethylenedi-5-nobornene-2,3-dicarboximide. (4) N,N'-dodecamethylenedi-5-nobornene-2,3-dicarboximide. (5) N,N'-Bis [-12-1/2-norbornene-2-3-dicarboximididolodecyl] - 1,2,3,4-bitans/stira-carboxylic 1,2,3,4-diimide The structures of these compositions were established by elemental analysis, IR, NMR, and mass spectra.

# N79-28316\* | IIT Research Inst. Chicago III. PROGRAM FOR PLASMA-SPRAYED SELF-LUBRICATING COATINGS Finel Report

G. C. Walther Jul. 1979 81 p refs

(Contract NAS3-20827)

(NASA-CR-3163: D6146) Avail NTIS HC A05/MF A01 CSCL

A method for preparing composite powders of the three coating components was developed and a procedure that can be used in applying uniform coatings of the composite powders was demonstrated Composite powders were prepared by adjusting particle sizes of the components and employing a small amount of monoaluminum phosphate as an inorganic binder. Quantitative microscopy (image analysis) was found to be a convenient method of characterizing the composition of the multiphase plasma-sprayed coatings. Area percentages and distribution of the components were readily obtained by this method. The adhesive strength of the coating to a nickel-chromium alloy substrate was increased by about 40 percent by a heat treatment of 20 hours at 550 C.

S.E.S.

N79-29331\*# United Technologies Research Center, East Hartford, Conn

#### NEW HIGH TEMPERATURE CROSS LINKING MONO-MERS

Daniei A Scola 20 Dec 1979 115 p refs

(Contract NAS3-21009)

(NASA-CR-159514, UTRC/R78-912897 15) Avail NTIS HC A06/MF A01 CSCL 07C

Several PMR polyimide resins capable of being processed at a maximum temperature of 232 C to 238 C without sacrifice of high temperature capability were developed. Four monomethyl esters were synthesized and characterized for use in the crosslinking studies. The infrared and DSC studies of each crosslinker suggested that curing could be accomplished at 288 C However, fabrication of dense, void free polymer specimens required a temperature of 316 C and a pressure of 0.69 MPa (100 psi) Crosslinkers were evaluated in Celion 6000/PMR polyimide composites. These composites were characterized at RT 288 C and 316 C initially and after isothermal aging at 288 C and 316 C for several hundred hours. The results suggest that both PMR systems are promising candidates as matrices for addition type polyimide composites. It is demonstrated that alternate crosslinkers are feasible but mechanisms to lower the crosslinking temperature must be developed to provide lower temperature processing PMR-type polyimides

### N79-30377\*# Horizons Research Inc. Cleveland, Ohio SURVEY OF INORGANIC POLYMERS

Arthur H. Gorber and Eugane F. McInerney, Jun. 1979, 316 p. refs.

Contract NAS3 21369)

(NASA CR 159563 HRI 396) Avail NTIS HC A14/MF A01 CSCL 07C

A literature search was carried out in order to identify inorganic, metallo organic, and hybrid inorganic organic polymers that could serve as potential matrix resins for advanced composites. The five most promising, andidates were critically reviewed and recommendations were made for the achievement of their potential in terms of performance and cost. These generic polymer classes complise [1] Polylarylsil sesquioxanesi 2) Polytsilyl arylene siloxanes: (3) Polytsilarylenes: (4) Poly is licon linked ferrocenes) and (5) Polylorgano phosphazenes) No single condidate currently possesses the necessary combination of physicomechanical properties, thermal stability processability. and favorable economics. The first three classes exhibit the best thermal performance. On the other hand poly lorgano nhi sphazenesi, the most extensively studied polymer class, exhibit tile best combination of structure property control processability. and tarorable economics

A79-31957 \* Static evaluation of surface coatings for compliant gas bearings in an oxidizing atmosphere to 650 C. B. Bhushan and S. Gray (Mechanical Technology, Inc., Latham, N.Y.). In: Metallurgical coatings 1978; Proceedings of the Fifth International Conference, San Francisco, Calif., April 3-7, 1978. Volume 1. (A79-31951 12-23) Lausanne, Elsevier Sequoia, S.A., 1978, p. 3-3-3-3-3-1, 7 ref., Contract No. NAS3-19427.

Hard wear-resistant coatings and soft low shear strength coatings were developed for an air-lubricated compliant journal bearing for a future automotive gas turbine engine. The coatings were expected to function in either 540 or 650 C ambient. Soft lubricant coatings were generally limited in temperature. Therefore emphasis was on the hard wear-resistant coatings. The coating materials covered were TiC, B4C, Cr3C2, WC, SiC, CrB2, TiB2, Cr2O3, Al2O3, Si3N4, Tribaloy 800, CaF2, CaF2-BaF2 eutectic, Ni-Co, silver, CdO-graphite and proprietary compounds. The coatings on test coupons were subjected to static oven screening tests. The test consisted of exposure of material samples in an oven for 300 h at the maximum temperature (540 or 650 C) and ten temperature cycles from room temperature to the maximum service temperature. On the basis of the specimen examinations the following coatings were recommended for future wear tests: TiC (sputtered), Cr2O3 (sputtered), Si3N4 (sputtered), CdO and graphite (fused), Kaman DES (a proprietary coating), CrB2 (plasma sprayed), Cr3C2 (detonation gun) and NASA PS-106 (plasma sprayed).

A79-51103 \* UV blocking filters for polymeric films. G. J. Rayl (General Electric Co., Space Div., Valley Forge, Pa.). American Vacuum Society, Meeting, Princeton, N.J., May 17, 1979, Paper. 17 p. 5 rels. Contract No. NAS

The concept of incorporating UV screening agents in silicone tesins as a means of protecting underlying solar cell covers and adhesives from UV degradation is presented. A silicone hard-coat resin incorporating a UV screening agent was selected as a suitable coating material for PEA Teffon solar cell covers. Consideration is given to fabrication procedures and techniques for introduction of the UV screening agents into silicone resins and application of these UV-introduct coatings to the Teffons. Some preliminary environmental tests, such as thermal shock and temperature humidity, were considered.

### 28 PROPELLANTS AND TUELS

Includes rocket propellants, ig. ters, and oxidizers, storage and handling, and aircraft juels.

For related information see also 07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, and 44 Energy Production and Conversion

N79-13196\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### CHARACTERISTICS AND COMBUSTION OF FUTURE HYDROCARBON FUELS

R. A. Rudey and J. S. Grobman In AGARD Aircraft Eng. Future Fuels and Energy Conserv. Sep. 1978 23 p. refs (For primary document see N79-13192 04-28)

Avail NTIS HC A0S/MF A01 CSCL 21D

Changes in fuel properties that are expected in future hydrocarbon fuels for aircraft are discussed along with the principal properties of syncrudes and the fuels that can be derived from them. The impact that the resultant potential changes in fuel properties may have on combustion and thermal stability characteristics is illustrated and discussed in terms of ignition, soot formation, carbon deposition, flame radiation, and emissions.

N79- 319/\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### IMPACT OF FUTURE FUEL PROPERTIES ON AIRCRAFT ENGINES AND FUEL SYSTEMS

R. A. Rudey and J. S. Grobman In AGARD Aircraft Eng. Future Fuels and Energy Conserv. Sep. 1978 29 p. refs (For primary document see N79-13192 04-28). Avail NTIS HC A09/MF A01 CSCL 21D

The affect of modifications in hydrocarbon jet fuels specifications on engine performance, component durability and maintenance, and aircraft fuel system performance is discussed. Specific topics covered include specific fuel consumption; ignition at relight limits, exhaust emissions, combustor liner temperatures, carbon deposition; gum formation in fuel nozzles, erosion and corrosion of turbine blades and vanes, deposits in fuel system heat exchangers; and pumpability and flowability of the fuel. Data that evaluate the ability of current technology aircraft to accept fuel specification changes are presented, and selected technological advances that can reduce the severity of the problems are described and discussed.

N79-15199\*# National Aeronautics and Space Administration Lewis Research Center, Cloveland, Ohio

### HIGH FREEZING POINT FUELS USED FOR AVIATION TURBINE ENGINES

Robert Friedman 1979 14 p refs To be presented at the 24th Ann Intern Gas Turbine Conf. San Diego, Calif. 11-15 Mar 1979 sponsored by ASME

(NASA TM 79015 E 9804) Avail NTIS HC A02/MF A01 CSCL 21D

Broadened specification aviation fuels could be produced from a greater fraction of crude source material with improvements in fuel supply and price. These fuels, particularly those with increased final boiling temperatures would have higher freezing temperatures than current aviation turbine fuels. For the small but significant fraction of commercial flights where low fuel temperatures maken higher freezing point fuel use unacceptable, adaptations to the flux of fuel system may be made to accommodate this fuel. Size of suchniques are discussed. Fuel heating is the most promoting non-cpt. One simple design uses existing heat rejection from it fuel lubricating oil cooler another uses an engine driven generator for electrical heating.

A R H

N79-16136\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

### EFFECT OF BROADENED SPECIFICATION FUELS ON AIRCRAFT ENGINES AND FUEL SYSTEMS

R. A. Rudey 1979 25 p. refs. To be presented at the 4th Intern. Symp. on Airbreathing Eng., Lake Buen Vista, Fla., 1-6 Apr. 1979, sponsored by AIAA

(NASA-TM-79086; E-9898) Avail NTIS HC A02/MF A01 CSCL 21D

A wide variety of studies on the potential effects of broadened-specification fuels on future aircraft engines and fuel systems are summarized. The compositions and characteristics of aircraft fuels that may be derived from current and future crude-oil sources are described, and the most critical properties that may effect aircraft engines and fuel systems are identified and discussed. The problems that are most likely to be encountered because of changes in selected fuel properties are explored, and the related effects on engine performance, component durability and maintenance, and aircraft fuel-system performance are examined. The ability of current technology to accept possible future fuel specification changes is assessed and selected technological advances that can reduce the severity of the potential problems are illustrated.

N79-20265°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

# AIRFOIL COOLING HOLE PLUGGING BY COMBUSTION GAS IMPURITIES OF THE TYPE FOUND IN COAL DERIVED FUELS

Daniel L Deadmore and Carl E Lowell Feb. 1979 14 p refs (Contract EF-77-A-01-2593)

(NA SA-TM-79076, E-9893; DOE/NASA/2593-79/1) Avail. NTIS HC A02/MF A01 CSCL 21D

The plugging of airfoil cooling holes by typical coal-derived fuel impurities was evaluated using doped combustion gases in an atmospheric pressure burner rig. Very high specific cooling air mass flow rates reduced or eliminated plugging. The amount of flow needed was a function of the composition of the deposit. It appears that plugging of film-cooled holes may be a problem for gas turbines burning coal-derived fuels.

N79-28349\*# National Aeronautics and Space Administration. Lewis Research Center Cleveland Ohio

### USE OF REFINERY COMPUTER MODEL TO PREDICT FUEL PRODUCTION

Francisco J Flores Jun 1979 25 p refs (NASA-TM-79203 E-088) Avail NTIS HC A02 MF A01 CSCL 21D

Several factors icrudes refinery operation and specifications) that affect yields and properties of broad specification jet fuel were parameterized using the refinery simulation model which can simulate different types of refineries were used to make the calculations. Results obtained from the program are used to correlate yield as a function of final boiling point, hydrogen content and freezing point for jet fuels produced in two refinery configurations, each one processing a different grude mix. Retinery performances are also compared in terms of energy consumption.

N79-28350\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

AYIAL JET MIXING OF ETHANOL IN CYLINDRICAL C TAINERS DURING WEIGHTLESSNESS

C Aydelott Jul 1979 43 p refs

INASA TP 1487 E 99371 Avail NTIS HC A03 MF A01 CSCL 21D

An experimental program was conducted to examine the liquid flow patterns that result from the axial jet mixing of ethanol in 10 centimeter diameter cylindrical tanks in weightlessness. A convex hemispherically ended tank and two Centaur liquid hydrogen tank models were used for the study. Four distinct liquid flow patterns were observed to be a function of the tank geometry, the liquid jet velocity, the volunte of liquid in the

tank, and the location of the tube from which the liquid jet exited. Author

N78-31403\*# National Aeronautics and Space Administration Lew ; Research Center, Cleveland, Ohio.

### THERMOPHYSICAL PROPERTY DATA: WHO NEEDS THEM?

R. C. Hendricks 1979 27 p refs Proposed for presentation at the Winter Ann. Meeting of the ASME, N Y, 2-7 Dec 1979

(NASA-TM-79241, E-149) Avail NTIS HC A03/MF A01 CSCL 07D

Specific examples are cited to illustrate the universal needs and demands for thermophysical property data. Applications of the principle of similarity in fluid mechanics and heat transfer and extensions of the principle to fluid mixtures are discussed. It becomes quite clear that no matter how eloquent theories (or experiments) in fluid mechanics or heat transfer are, results of their application can be no more accurate than the thermophysical properties required to transform these theories into practice—or in the case of an experiment, to reduce the data. Present day projects take place on such a scale that the need for international standards groups and mutual cooperation is evident.

N79-31405\*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

### COMPARISON OF THE PROPERTIES OF SOME SYNTHETIC CRUDES WITH PETROLEUM CRUDES

Albert C Antoine Jul 1979 31 p refs (NASA-IM-79220 E 115) Avail NTIS HC A03/MF A01 CSCL

Physical properties and chemical compositions of six synthetic crudes were determined. The results were compared to those of typical petroleum crudes with the interest being the feasibility of making let fuels from oil shale and coal syncrudes. The specific gravity, viscosity, and pour point were measured showing that tiese crudes would be described as heavier rather than lighter crudes. The boiling range distribution of the crudes was determined by distillation and by gas chromatography. In addition, gelpermeation chromatograms were obtained giving a unique molecular weight distribution profile for each crude. Analyses for carbon, hydrogen, nitrogen, and sulfur concentrations, were performed, as well as for hydrocarbon group type and trace element concentrations. It was found that the range in concentration of variadium an element whose presence in turbine fuels is of major concern, was lower than that of petroleum crudes Sodium and potassium other elements of concern were present in comparatively high concentrations

A79-10824 \* = Alternative aircraft fuels. J. P. Longwell (MIT, Can bridge, Mass.) and J. Grobman ((IASA, Lewis Research Center Cliverland, Ohio). American Society of Mechanical Engineers. Gas Turbine Conference and Products Show, London, England, Apr. 9-13-1978, Paper. 21 p. 11 refs.

In connection with the anticipated impossibility to provide on a long term basis liquid fuels derived from petroleum, an investigation has been conducted with the objective to assess the suitability of jet tuels made from pill shale and coal and to develop a data base which will allow optimization of future fuel characteristics. Taking energy efficiency of manufacture and the tradeoffs in allocation and engine design into account. The properties of future aviation fuels are examined and proposed solutions to problems of alternative fuels are discussed. Attention is given to the refining of jet fuel to nument specifications the contral of fuel thermal stability, and combustor technology for use of bread specification fuels. The first solution is to contral a develop the reconstant technology at the retinery to produce specification into coloring cations jet fuels covaries.

A79-11599 \* # Characteristics and combustion of foure hydrocarbon fuels. R. A. Rudey and J. S. Grobman (NAS.'A., Lewis Research Center, Cleveland, Ohio). NATO, AGARD, Lecture Series on Energy Conservation in Aircraft Propulsion, Munich, West Germany, Oct. 26, 27, 1978, Paper. 25 p. 19 refs.

Dwindling supply of high-quality crude is beginning to manifest itself in the form of crude oils containing higher percentages of aromatic compounds, sulfur, nitrogen, and trace constituents. In the present paper, problems which have arisen with regard to the hydrogen content in jet fuels derived from these crude oil sources are discussed, with particular reference to the effects of varying the fuel properties on the combustion and thermal stability characteristics of a fuel. The importance of knowing how severe the effects of variations in hydrogen content, fuel-bound-nitrogen content, and boiling range are on such combustion phenomena as soot and carbon formation, emissions, and ignition is pointed out.

V.P.

A79-12378 \* # Alternative aviation turbine fuels. J. Grobman (NASA, Lewis Research Center, Advanced Technology Section, Cleveland, Ohio). In: National Conference on Energy Conservation in General Aviation, 1st, Kalamazoo, Mich., October 10, 11, 1977, Promedings. (A79-12376 02-07) Kalamazoo, Mich., Western Michigan University, 1977, p. 40-59, 11 refs.

The efficient utilization of fossil fuels by future jet aircraft may necessitate the broadening of current aviation turbine fuel specifications. The most significant changes in specifications would be an increased aromatics content and a higher final boiling point in order to minimize refinery energy consumption and costs. These changes would increase the freezing point and might lower the thermal stability of the fuel and could cause increased pollutant emissions, increased smoke and carbon formation, increased combustor liner temperatures, and poorer ignition characteristics. This paper discusses the effects that broadened specification fuels may have on present-day jet aircraft and engine components and the technology required to use fuels with broadened specifications. (Author)

A79-30555 \* High-freezing-point fuels used for aviation turbine engines. R. Friedman (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-141, 12 p. 21 refs.

Broadened-specification aviation fuels could be produced from a greater fraction of crude source muterial with improvements in fuel supply and price. These fuels, particularly those with increased final boiling temperatures, would have higher freezing temperatures than current aviation turbine fuels. The higher-freezing-point fuels can be substituted in the majority of present commercial flights, since temperature data indicate that in-flight fuel temperatures are relatively mild. For the small but significant fraction of commercial flights where low fuel temperatures make higher freezing-point fuel use unacceptable, adaptations to the fuel or fuel system may be made to accommodate this fuel. Several techniques are discussed. Fuel heating is the most promising concept. One simple system design uses existing heat rejection from the fuel-lubricating oil cooler, another uses an engine-driven generator for electrical heating. Both systems offer advantages that outweigh the obvious penalties. (Author)

A79-38980 \* # Analysis of the impact of the use of broad specification fuels on combustors for commercial aircraft gas turbine engines. E. J. Szetela (United Technologies Research Center, East Hartfori, Conn.), R. P. Lehmann (United Technologies Corp., Pratt and Whithe, Aircraft Group, East Hartford, Conn.), and A. L. Smith INASA, Lewis Research Center, Cicveland, Ohio). AIAA, SAE, and ASME. Joint Propulsion Conference, 15th. Las Vegas, Nev. June 18-20, 1979, AIAA Paper 79-1195, 11 p. 16 refs.

An analytical study was conducted to assess the impact of the use of broad specification fuels with reduced hydrogen content on the design performance, durability, emissions and operational characteristics of combustors for commercial aircraft gas turbine

engines. The study was directed at defining necessary design revisions to co-nbustors designed for use of Jet A when such are operated on ERBS (Experimental Referee Broad Specification Fuel) which has a nominal hydrogen content of 12.8 percent as opposed to 13.7 percent in current Jet A. The results indicate that improvements in combustor liner c. Dling, and/or materials, and methods of fuel atomization will be required if the hydrogen content of aircraft gas turbine fuel is decreased. (Author)

#### N79-10226\*# Southwest Research Inst. San Antonio, Tex-WORKBOOK FOR ESTIMATING EFFECTS OF ACCIDENTAL EXPLOSIONS IN PROPELLANT & YOUND HANDLING AND TRANSPORT SYSTEMS Final (aport)

W E Baker, J J Kulesz, R E Ricker, P S Westine, V B Parr, L M Vargas, and P K Moseley Aug 1978 274 p refs (Contract NAS3:20497)

(NASA-CR-3023, Rept-02-4778) Avail NTIS HC A12/MF A01 CSCL 21D

A workbook is presented to supplement an earlier NASA publication which was intended to provide the designer and safety engineer with rapid methods for predicting damage and hazards from explosions of liquid propellant and compressed gas vessels used in ground storage, transport and handling. Information is presented in the form of graphs and tables. How easy calculation, using only desk or handheld calculators. Topics covered in various chapters are. [1] estimates of explosive yield. [2] characteristics of pressure waves. [3] effects of pressure waves. [4] characteristics of fragments, and (5) effects of fragments and related topics.

N79-20266 $^{\bullet}$ # General Applied Science Labs., Inc., Westbury, N Y

#### PREMIX FUELS STUDY APPLICABLE TO DUCT BURNER CONDITIONS FOR A VARIABLE CYCLE ENGINE Final Report

K. S. Venkataramani. Dec. 1978. 44 p. refs. (Contract NAS3-20603)

(NASA-CR-159513, TR-251) Avail NTIS HC A03/MF A01 CSCL 21D

Emission levels and performance of a premixing Jet-A/air duct burner were measured at reference conditions representative of take-off and cruise for a variable cycle engine. In a parametric variation sequence of tests, data were obtained at inlet temperatures of 400, 500 and 600K at equivalence ratios varying from 0.9 to the lean stability limit. Ignition was achieved at all the reference conditions although the CO levels were very high Significant nonuniformity across the combustor was observed for the emissions at the take-off condition. At a reference Mach number of 0.117 and an inlet temperature of 600K, corresponding to a simulated cruise condition, the NOx emission level was approximately 1 gm/kg-fuel.

## N79-20267\*# Exxon Research and Engineering Co., Linden, N. J. HIGH PERFORMANCE, HIGH DENSITY HYDROCARBON FUELS

J W Franken eld T W Hastings M Lieberman, and W F Taylor Oct 1978 239 p refs

(Contract NAS3-20394)

(NASA-CR-159480, EY ON/GRUS 1KWD 78) Avail NTIS HC A11/MF A01 CSCL 21D

The fuels were selected from 77 original candidates on the basis of estimated merit index and cost effectiveness. The ten candidates consisted of 3 pure compounds, 4 chemical plant streams and 3 refinery streams. Critical physical and chemical properties of the candidate fuels were measured including heat of combustion, density, and viscosity as a function of temparature freezing points, vapor pressure, boiling point, thermal stability. The best all around candidate was found to be a chemical plant olefin stream rich in dicyclopentadiene. This material has a high merit index and is available at low cost. Possible problem areas were identified as low temperature flow properties and thermal stability. An economic analysis was carried out to determine the production costs of top candidates. The chemical plant and refinery streams were all less than 44 centriky while the pure

compounds were greater than 44 cent/kg. A literature survey was conducted on the state of the art of advanced hydrocarbon fuel technology as applied to high energy propellents. Several areas for additional research were identified.

L.S.

# N79-24172\*# Boeing Commercial Airplane Co., Seattle, Wash, DESIGN AND EVALUATION OF AIRCRAFT HEAT SOURCE SYSTEMS FOR USE WITH HIGH-FREEZING POINT FUELS Final Report

A. J. Pasion NASA May 1979 53 p .efs

(Contract NAS3-20815)

NASA-CR-159568: D6-48097) Avail NTIS

HC A03/ MF A01 CSCL 21D

The objectives were the design, performance and economic analyses of practical aircraft fuel heating systems that would permit the use of high freezing-point fuels on long-range aircraft. Two hypothetical hydrocarbon fuels with freezing points of -29 C and -18 C were used to represent the variation from current day jet fuels. A Boeing 747-200 with JT9D-7/7A engines was used as the baseline aircraft. A 9300 Km mission is seen used to mission length from which the heat requirements to maintain the fuel above its freezing point was based.

J.A.M.

# N79-26221\*# General Electric Co., Evendale, Ohio. EXPERIMENTAL CLEAN COMBUSTOR PROGRAM: DIESEL NO. 2 FUEL ADDENDUM, PHASE 3 Final Report

C. C. Gleason and D. W. Bahr. May 1979. 66 p. refs. (Contract NAS3-19736)

(NASA-CR-135413, R79AEG367) Avail NTIS HC A04/MF A01 CSCL 1D

A CF6-50 engine equipped with an advanced, low emission, double annular combustor was operated 4.8 hours with No. 2 diesel fuel. Fourteen steady-state operating conditions ranging from idle to full power were investigated. Engine/combustor performance and exhaust emissions were obtained and compared to JF-5 fueled test results. With one exception, fuel effects were very small and in agreement with previously obtained combustor test rig results. At high power operating condition, the two fuels produced virtually the same peak metal temperatures and exhaust emission levels. At low power operating conditions, where only the pilot stage was fueled, smoke levels tended to be significantly higher with No. 2 diesel fuel. Additional development of this combustor concept is needed in the areas of exit temperature distribution, engine fuel control, and exhaust emission levels before it can be considered for production engine use.

# N79-29365\* Lockheed-California Co. Burbank EXPERIMENTAL STUDY OF LOW TEMPERATURE BEHAVIOR OF AVIATION TURBINE FUELS IN A WING TANK MODEL Final Report

Francis J Stockemer 1979 112 p refs

(Contract NAS3-20814)

(NASA CR 159815) Avail NTIS HC A06/MF A01 CSCL 21D

An experimental investigation was performed to study aircraft fuels at low temperatures near the freezing point. The objective was an improved understanding of the flowability and pumpability of the fuels under conditions encoutered during cold weather flight of a long range commercial aircraft. The test tank simulated a section of an order wing tank and was chilled on the upper and lower surface:

— els included commercial Jet A and Diesel D.2. JP-5 from oil, ale and Jet A intermediate freeze point, and D.2 fuels derived from selected paraffinic and naphthenic crudes. A pour point depressant was tested.

M.M.M.

N75 25382" TRW, Inc. Cleveland, Ohio

AUTOMATE() PLASMA SPRAY (APS) PROCESS FEASIBILITY STUDY: PLASMA SPRAY PROCESS DEVELOPMENT AND EVALUATION Interim Report

C. W. Fetheroff, T. Derkacs, and I. M. Matay. May 1979, 117 p. refs.

(Contract NAS3-20112)

(NAS/,-CR-159579, TRW-ER-8019-1) Avail NTIS HC A06/MF A01 CSCL 13H

An automated plasma spray (APS) process was developed to apply two layer (NiCrAlY and ZrO2-12Y2O3) thermal-barrier coatings to aircraft gas turbine engine blade airfoils. The APS process hardware consists of four subsystems: a mechanical blade positioner incorporating two interlaced six-degree-of-freedom assemblies a noncoherent optical metrology subsystem, a microprocessor-based adaptive system controller, and commercial plasma spray equipment. Over fifty JT9D first stage turbine blades specimens were coated with the APS process in preliminary checkout and evaluation studies. The best of the preliminary specimens achieved an overall coating thickness uniformity of + or - 53 micrometers, much better than is achievable manually Factors limiting this performance were identified and process modifications were initiated accordingly. Comparative evaluations of coating thickness uniformity for manually sprayed and APS coated specimens were initiated. One of the proliminary evaluation specimens was subjected to a torch test and metallographic evaluation

### 31 ENGINEERING (GENERAL)

Includes vacuum technology; control engineering display engineering, and cryogenics.

N79-21225\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### LOW HEAT LEAK CONNECTOR FOR CRYOGENIC SYSTEM Patent

Philip D Stelts, inventors (to NASA) (Air Products and Chemical Inc., Philadelphia) Issued 2 Nov. 1965 6 p. Filed 1 Oct. 1964 Sponsored by NASA

(NASA-Case-XLE-02367-1, US-Patent-3,215,313;

US-Patent-Appl-SN 400857, US-Patent-Class-222-131) Avail US Patent and Trademark Office CSCL 20L

Heat leak from the surrounding atmosphere during fluid tri isfer from a spaced shell-insulated vessel for storing liquified gas having an upper gaseous phase, in minimized by forming a relatively wide, shallow blister on the wall of the vessel at the point of transfer line connection. The shell and the opposed walls of the blister have aligned openings whose common axis passes centrally through the blister and is normal to the surfaces of the vessel and shell. A fluid transfer line conduit passing through the shell opening is in fluid-tight connection with the shell and blister wall. The fluid transfer line confines the fluid in a continuous stream. The blister is filled with a heat insulating material which provides a thermal break between the central wall portions of the blister. A connector at the bottom of the vessel comprises a tube extending between the openings in the blister which projects a short distance within the body of liquefied gas and terminates in a reverse bend to prevent backflow of liquid through the pipe

N79-23257°# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio.

### IDENTIFICATION AND DUAL ADAPTIVE CONTROL OF A TURBOJET ENGINE

Walter Merrill and Gary Leininger (Toledo Univ.) 1979 10 p. refs. Proposed for presentation at the 5th IFAC Symp on Identification and System Parameter Estimation, Darmstadt, West Ger. 24-28 Sep. 1979

(NASA-TM-79145, E-10000) Avail NTIS HC A02/MF A01 CSCL 21E

The objective of this paper is to utilize the design methods of modern control theory to realize a dual-adaptive feedback control unit for a highly nonlinear single spool airbreathing turbojet ungine Using a very detailed and accurate simulation of the nonlinear engine as the data source, linear operating point models of unspecified dimension are identified. Feedback control laws are designed at each operating point for a prespecified set of sampling rates using sampled data output regulator theory. The control system sampling rate is determined by an adaptive sampling algorithm in correspondence with turbolet engine performance. The result is a dual adaptive control law that is functionally dependent upon the sampling rate selected and environmental operating conditions. Simulation transients demonstrate the utility of the dual-adaptive design to improve on board computer utilization while maintaining acceptable levels of engine performance Author

A79-19816 \* - Some flow phenomena in a constant area duct with a Borda type inlet including the critical region. R. C. Hendricks and P. J. Simoneau (INASA Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers. Winter Annual Meeting. San Francisco, Calif. Dec. 10.15, 1973, Paper 78 WA/HT 37, 7 in 13 refs. Members, \$1.50, nonnembers, \$3.00.

Mass limiting flow characteristics for a 55 L D tube with a Borda type inlet have been assessed over large ranges of temperature and pressure using fluid introgen. Under certain conditions, separation and pressure drop at the inlet was sufficiently strong to permit partial vaporization and the remaining fluid flowed through the tube as if it were a free set. An empirical relation was determined which defines conditions under which this type of flow can occur. A flow

coefficient is presented which enables one to estimate flow rates over the experimental range. A flow rate stagnation pressure map for selected stagnation isotherms and pressure profiles document these flow phenomena. (Author)

N79-30415\*# Boeing Engineering and Construction, Seattle, Wash

#### MOD-2 FAILURE MODE AND EFFECTS ANALYSIS

Robert Lynette and Robert Poore Jul. 1979 302 p. Sponsored by NASA

(Contract DEN3-2: DE-AI01-79ET20485)

(NASA-CR-159632) Avail NTIS HC A14/MF A01 CSCL

The results of a failure mode and effects analysis of the Mod-2 wind turbine are presented Author

#### 32 COMMUNICATIONS

Includes land and global communications; communications theory; and optical communications.

For related information see also 04 Aircraft Communications and Navigation and 17 Spacecraft Communications, Command and Tracking.

N79-14276\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN OF A VIDEO TELECONFERENCE FACILITY FOR A SYNCHRONOUS SATELLITE COMMUNICATIONS LINK Michael D. Richardson Jan. 1979 20 p refs

(NASA-TP-1376; E-9202) Avail NTIS HC A02/MF AU1 CSCL 17B

The system requirements, design tradeoffs, and final design of a video teleconference facility are discussed, including proper lighting, graphics transmission, and picture aesthetics. Methods currently accepted in the television broadcast industry are used in the design. The unique problems associated with using an audio channel with a synchronous satellite communications link are discussed, and a final audio system design is presented.

Author

N79-16169\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### TELECOMMUNICATION SERVICE MARKETS THROUGH THE YEAR 2000 IN RELATION TO MILLIMETER WAVE SATELLITE SYSTEMS

Steven M. Stevenson 1979 13 p. Presented at the Intern. Telecommunication Exposition, Dallas, 26 Feb. 2 Mar 1979 (NASA-TM-79099) Avail NTIS HC A02/MF AC1 CSCL 17B

NASA is currently conducting a series of millimeter wave satellite system market studies to develop 30/20 GHz satellite system concepts that have commercial potential. Four contractual efforts were undertaken, two parallel and independent system studies and two parallel and independent market studies. The marketing efforts are focused on forecasting the total domestic demand for long haul telecommunications services for the 1980-2000 period. Work completed to date and reported in this paper include projections of geographical distribution of traffic, traffic volume as a function of urban area size; and user identification and forecasted demand.

N79-17072\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

# DETERMINING POTENTIAL 30/20 GHz DOMESTIC SATELLITE SYSTEM CONCEPTS AND ESTABLISHMENT OF A SUITABLE EXPERIMENTAL CONFIGURATION

Grady H Stevens and Godfrey Anzic 1979 19 p. refs. Presented at the Intern. Telecommun. Exposition, Dallas. 26 Feb. 1976 - 2 Mar. 1979

(NASA-TM-79092 E-9916) Avail NTIS HC A02/MF A01 ISCL 17B

NASA is conducting a series of millimeter wave satellite communication systems and market studies to (1) determine potential domestic 30/20 GHz satellite concepts and market porential, and (2) establish the requirements for a suitable technology verification payload which, although intended to be modest in capacity, would sufficiently de-nonstrate key technologies and experimentally address key operational issues. Preliminary results and critical issues of the current contracted effort are described. Also included is a description of a NASA-developed multibeam satellite payload configuration which may be representative of concepts utilized in a technology flight verification program.

N79-20300" National Aeronautics and Space Administration.

RESULTS OF THIN-ROUTE SATELLITE COMMUNICATION SYSTEM ANALYSES INCLUDING ESTIMATED SERVICE COSTS

David L Wright 1979 12 p ref Presented at the Intern Telecommun Exposition, Dallas, 26 Feb - 2 Mar. 1979 Prepared

in cooperation with Fairchild Space and Electronics Co., Germantown, Md.

(Contract NAS3-20364)

(NASA-TM-79098; E-9922) Avail: NTIS HC A02/MF A01 CSCL 178

A variety of cost and performance tradeoffs are addressed and the preliminary design of a communications satellite system capable of meeting isolated rural users' needs is presented. Small inexpensive rural earth stations are linked via the satellite to a nation wide network of large earth stations which are, in turn, interconnected to the switching exchanges of the conventional telephone network. Optimum earth station EIRP and G/T and satellite transponder power are defined as a function of a wide variety of system options.

G.Y.

N79-23313\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### VHF DOWNLINE COMMUNICATION SYSTEM FOR SLAR

R. J. Schertler, T. L. Chase, R. A. Mueller, I. Kramarchuk, R. J. Jirberg, and R. T. Gedney. 1979. 10 p. refs. Presented at the 13th Intern. Symp. on Remote Sensing of Environment, Ann Arbor. Mich., 23-27. Apr., 1979, sponsored by Michigan Univ. (NASA-TM-79164, E-025). Avail. NTIS. HC. A02/MF. A01. CSCL. 171.

A real time VHF downlink communication system is described for transmitting side-looking airborne radar (SLAR) data directly from an aircraft to a portable ground/shipboard receiving station. Use of this receiving station aboard the U.S. Coast Guard cebreaker Mackinaw for generating real-time photographic quality radar images is discussed. The system was developed and demonstrated in conjunction with the U.S. Coast Guard and NOAA National Weather Service as part of the Project Icewarn all weather ice information system for the Great Lakes Winter Navigation Program.

N79-27351\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

### SATELLITE COMMUNICATIONS FOR DISASTER RELIEF OPERATIONS

Joseph N. Sivo. 1979. 20 p. refs. Proposed for presentation at Intern. Astron. Federation Munich, 17-23. Sep. 1979. (NASA-TM-7S198, E-078). Avail. NTIS. HC. A02/MF. A01. CSCL. 178.

The use of existing and planned communication satellite systems to proveide assistance in the implementation of disaster relief operations on a global basis was discussed along with satellite communications system implications and their potential impact on field operations in disaster situations. Consideration are given to the utilization of both INTELSAT and MARISAT systems operating at frequencies ranging from 1.5 to 4 GHz and to the size and type of ground terminals necessary for satellite access. Estimates of communication requirements for a global system are given. Some discussion of cost estimates for satellite services to support operations are included Studies of communication satellites for both pre and post disaster applications conducted for NOAA are included as well as recent experiments conducted in conjunction with the Office of Foreign Disaster Assistance of the Agency for International Development

N79-33379\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

CARRIER: INTERFERENCE RATIOS FOR FREQUENCY SHARING BETWEEN SATEILITE SYSTEMS TRANSMITTING FREQUENCY MODULATED AND DIGITAL TELEVISION SIGNALS

Scott P Barnes 1979 8 p refs. To be presented at the Natl Telecommun. Conf., Washington, D. C., 26-28 Nov. 1979, sponsored by IEEE.

(NASA-TM 79265 E 180) Avail NTIS HC A02/M5 A01 CSCL 17B

Results are presented of subjective and quantitative tests describing the results of interference to a particular digital television system from a frequency modulated (FM), television

6.3

system, and for interference to an FM television system from a digital television system.

M.M.M.

A79-14948 \* # 20/30 GHz satellite systems technology needs assessment. G. Stevens and D. Wright (NASA, Lewis Research Center, Cleveland, Ohio). Instrument Society of America, International Telemetering Conference, Los Angeles, Calif., Nov. 14-16, 1978, Paper, 12 p. 8 refs.

The paper surveys the system and market work done at NASA-Lewis with regard to exploring the potential of the 20/30 GHz bands for domestic satellite communications. The 20/30 GHz bards appear attractive economically and, with certain technology advances, appear to offer a virtually unlimited spectrum resource. This attractiveness is especially relevant to high density trunking where there is sufficient traffic to justify dual-station site diversity. Ongoing system and market studies actively involve satellite system suppliers and carriers as well as the government in a cooperative, mutually beneficial effort. It is considered that this is the approach most likely to result in a spect-um-efficient acceptable-risk high-capacity 30/30 GHz satellite system which is relevant to anticipated markets.

A79-27397 \* Determining potential 30/20 GHz domestic satellite system concepts and establishment of a suitable experimental configuration. G. H. Stevens and G. Anzic (NASA, Lewis Research Center, Cleveland, Ohio). International Telecommunication Exposition, Dallas, Tex., Feb. 26-Mar. 2, 1979, Paper. 19 p. 6 refs.

Issues and results in a NASA study of the potential concepts and markets for a multibeem 30/20 GHz domestic satellite system in the 1990s are presented. Issues considered include the reduction of signal attenuation due to rain, beam-beam interference isolation in the multibeam system, the method of access/modulation (FDMA, TDMA or hybrid) and the market for reduced reliability and wideband services. A hypothetical demonstration payload configuration which would attempt to resolve these issues is illustrated. The communications payload would employ a system of seven configuous coverage spots in order to demonstrate a typical cell in a contiguous beam system having extensive frequency reliase, as in a direct-to-user system, and a single spot, typical of a trunking system, to determine signal isolation. The payload could be carried on several existing buses and is illustrated on an MMS bus.

A.L.W.

A79-27398 \* # Telecommunication service markets through the year 2000 in relation to millimeter wave satellite systems. S. M. Stevenson (NASA, Lewis Research Center, Cleveland, Ohio). International Telecommunication Exposition, Dallas, Tex., Feb. 26-Mar. 2, 1979, Paper. 12 p.

NASA is currently conducting a series of millimeter wave satellite system and market studies to develop 30/20 GHz satellite system concepts that have commercial potential for the period 1980-2000. The results of the market studies to-date focusing on the overall demand forecasts and distributions by geographic location, distance, and user category are discussed. Tables are presented indicating baseline market forecast voice and video services, data service category, impacted baseline forecast, and traffic/distance distribution voice services. It is concluded that the total market and system activity will be influential in determining the potential role of millimeter wave systems in the overall transmission needs of the nation, and the amount of the total forecasted traffic suitable for millimeter wave systems.

A.A.

A79-29784 \* Millimeter wave communication satellite concepts. L. D. Holland, N. B. Hilsen, R. W. Wallace (Georgia Institute of Technology, Atlanta, Ga.), and G. Stevens (NASA, Lewis Research Center, Cleveland, Ohio). In Canadian Communications and Power Conference, Montreal, Canada, October 18-20, 1978, Proceedings. (A79-29776.11-32). New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 93-95.5 refs. Contract No.

NAS3-20110.

Methodology has been developed for identifying viable and appropriate technologies for future NASA millimeter wave research as based upon the technical requirements of potential space communication services. Applicability of the methodology has been verified through its use with two conceptual communications systems. The subsystem cost and weight models are the appropriate level of detail for this study. Application of the methodology to the detailed design of a satellite system would require further model refinement.

A79 30394 \* # Global disaster satellite communications system for disaster assessment and relief coordination. B. E. LeRoy (NASA, Lewis Research Center, Cleveland, Ohio). International Telecommunication Exposition, Dallas, Tex., Feb. 26-Mar. 2, 1979, Paper. 10 p. 6 refs.

Global communication requirements for disaster assistance are analyzed in the light of operationally feasible satellite system concepts and associated system parameters. Present and planned commercially available systems are considered, together with an assessment of the associated global disaster ammunication yearly service costs. It is concluded that a likely number of transportable terminals required for long distance relief communications activities would be less than 10, with the transportation costs not expected to exceed 25% of the annual systems' cost. Consequently, no sound economic justification is seen for ground terminal development for the global disaster communications system.

A.A.

A79-30395 \* # Results of thin-route satellite communication system analyses including estimated service costs. D. L. Wright (NASA, Lewis Research Center, Cleveland, Ohio). International Telecommunications Exposition, Dallas, Tex., Feb. 26-Mar. 2, 1979, Paper, 10 p. Contract No. NAS3-20364.

Ways for determining optimum satellite and terrestrial system architectures and parameters for providing the most economical telephone service to remote areas of the U.S. are explored. Several configurations for an isolated rural telephone system, covering all the states plus Alaska, employing satellites is considered. Both direct-to-the user and community-type of systems are evaluated using UHF and Ku-bar.d RF equipment for the rural/satellite links. The effect of multiple spot beams, outage, signal quality, modulation method, satellite accessing, forward error correction, and the number of users are also evaluated. The total cost for a 5-minute call from an isolated rural user to a TELCO user was shown to be as low as \$1.30 for a system with 1.8 X 10 to the sixth rural users.

A.A.

N79-12273\*# Fairchild Space and Electronics Co., Germantown, Md

## COMMUNICATIONS SYSTEMS TECHNOLOGY ASSESSMENT STUDY VOLUME 2: RESULTS Final Report

R L Kelley, R K Khatri, J D Kiesling, and J A Weiss Oct 1977 352 p

(Contract NAS3-20364)

(NASA-CR 135224) Avail NTIS HC A16/MF A01 CSCL 17B

The cost and technology characteristics are examined for providing special satellite services at UHF 2.5 GHz, and 14/12 GHz. Considered are primarily health, educational, informational and emergency disaster type services. The total cost of each configuration including space segment earth station, installation operation and maintenance was optimized to reduce the user's total annual cost and establish preferred equipment performance parameters. Technology expected to be available between now and 1985 is identified and comparisons made between selected alternatives. A key element of the study is a survey of earth station equipment updating past work in the field, providing new insight into technology, and evaluating production and test methods that can reduce costs in large production richs Various satellite configurations were examined. The cost impact of rain attenuation at Ku band was evaluated. The factors affecting the

ultimate capacity achievable with the available orbital arc and available bandwidth were analyzed

N79-17071\*# Dayton Univ. Research Inst., Ohio.

A CROSS IMPACT METHODOLOGY FOR THE ASSESS-MENT OF US TELECOMMUNICATIONS SYSTEM WITH APPLICATION TO FIBER OFFICS DEVELOPMENT: EXECU-TIVE SUMMARY Final Report

Joseph P Martino, Raleli Lenz, Jr. and Kuei-Lin Chen Jan. 1979 3c p

(Contract NAS3-20:

UDR-TR-79-17) NTIS (NASA-CR-135209. Avail HC A03/MF A01 CSCL 17B

A cross impact model of the U.S. telecommunications system was developed. For this model, it was necessary to prepare forecasts of the major segments of the telecommunications system, such as satellites, telephone, TV, CATV, radio broadcasting, etc. In addition, forecasts were prepared of the traffic generated by a variety of new or expanded services, such as electronic check clearing and point of sale electronic funds transfer. Finally, the interactions among the forecasts were estimated (the cross impacts) Both the forecasts and the cross impacts were used as inputs to the cross impact model, which could then be used to stimulate the future growth of the entire U.S. telecommunications system. By varying the inputs, technology changes or policy decisions with regard to any segment of the system could be evaluated in the context of the remainder of the system. To illustrate the operation of the model, a specific study was made of the deployment of fiber optics, through it the telecommunications system

N79-18159\*# Dayton Univ. Research Inst., Ohio

A CROSS IMPACT METHODOLOGY FOR THE ASSESS MENT OF US TELECOMMUNICATIONS SYSTEM WITH APPLICATION TO FIBER OPTICS DEVELOPMENT. **VOLUME 1 Final Report** 

Joseph P. Martino, Ralph C. Lenz, Jr., Kuei-Lin Chen, Peter Kahut, Robert Sekely, and John Weiler Jan 1979 220 p (Contract NAS3-20365)

(NASA-CR-159511, UDR-TR-79-18-Vol-1) Avail NTIS HC A10/MF A01 CSCL 17B

A cross impact model of the U.S. telecommunications system was developed it was necessary to prepare forecasts of the major segments of the telecommunications system, such as satellites, telephone, TV, CATV, radio broadcasting, etc. In addition, forecasts were prepared of the traffic generated by a variety of new or expanded services, such as electronic check clearing and point of sale electronic funds transfer. Finally, the interactions among the forecasts were estimated (the cross impact). Both the forecasts and the cross impacts were used as inputs to the cross impact model, which could then be used to stimulate the future growth of the entire U.S. telecommunications system. By varying the inputs, technology changes or policy decisions with regard to any segment of the system could be evaluated in the context of the remainder of the system. To illustrate the operation of the model, a specific study was made of the deployment of fiber optics throughout the telecommunications system. Author

N79-18160°# Dayton Univ Research Inst. Ohio

A CROSS IMPACT METHODOLOGY FOR THE ASSESS MENT OF US TELECOMMUNICATIONS SYSTEM WITH APPLICATION TO FIBER OPTICS DEVELOPMENT. **VOLUME 2 Final Report** 

Joseph P. Martino, Ralph C. Lenz, Jr., Kuei Lin Chen, Peter Kahut, Robert Sekely, and John Weiler Jan 1979 258 p refs (Contract NAS3-20365)

(NASA-CR-159511 UDR-TR-79-19-Vol-2) Avail NTIS HC A12/MF A01 CSCL 17B

The appendices for the cross impact methodology are presented. These include luser's guide, telecommunication events, cross impacts, projection of historical trends, and projection of trends in satellite communications FOS

N79-33373°# Hughes Aircraft Co., Los Angeles, Calif. Space and Communications Group

#### THE 18 AND 30 GHz FIXED SERVICE COMMUNICATION SATELLITE SYSTEM STUDY: EXECUTIVE SUMMARY Final Report

Leonard M. Bronstein Sep. 1979 11 p.

(Contract NAS3-21367)

(NASA-CR-159627-1; HAC-REF-E1992-1; SCG-90275R) Avail: NTIS HC A02/MF A01 CSCL 17B

The use of the 18 and 30 GHz bands for fixed service .. ary objectives were satellite communications is examined. to determine if satellite communication systems using this allocation (27.5 to 30.0 GHz uplink; 17.7 to 20.2 GHz downlink) can be cost competitive with alternate means of communication, and to determine what technological developments would be required to make these systems competitive. To meet these objectives, the cost and performance to be expected of 18 and 30 GHz hardware in the 1985 to 1990 era was assessed, selected trunking and direct to user concepts were optimized, and the cost of these systems was estimated Finally, the technology developments required to make the most promising of the concepts competitive were identified

N79-33374°# Hughes Aircraft Co., Los Angeles, Calif and Communications Group

### THE 18 AND 30 GHz FIXED SERVICE COMMUNICATIONS SATELLITE SYSTEM STUDY Final Report Leonard M Bronstein Sep 1979 297 p refs

(Contract NAS3-21367)

(NASA-CR-159627-2, HAC-Ref-E1992-2, SCG-90272R) Avail NTIS HC A13/MF A01 CSCL 17B

The use of the 18 and 30 GHz bands for fixed service satellite communications is examined. The cost and performance expected of 18 and 30 GHz hardware is assessed, selected trunking and direct to user concepts are optimized, and the cost of these systems are estimated. The effect of rain attenuation on the technical and economic viability of the system and methods circumventing the problem are discussed. Technology developments are investigated and cost estimates of these developments are presented

A79-33793 \* On the distribution of computation for sequential decoding using the stuck algorithm. R. Johannesson (Lund, Universitet, Lund, Sweden). IEEE Transactions on Information Theory, vo.: 1T-25, May 1979, p. 323-331, 18 refs. Research supported by the American-Swedish Foundation and L. M. Ericsson Telephone Co., Grant No. NGL 5025.

A method is developed for estimating the computational distribution for the stack algorithm for sequential decoding, that is, the probability that the computation required to decode the first branch of the free is greater than or equal to N, for small N. The analysis relies heavily on the theory of multitype branching processes. A step in the analysis is the determination of the distribution of the minimum of the cumulative metrics along the transmitted path in the code tree. This is used to obtain the distribution of the number of computations made by the decoder in order to decode the first branch in the tree, and this random variable serves as an approximation of the average number of computations per decoded branch. At information rates below the cutoff rate, the calculated computational performance is virtually identical to that obtained by time-consuming simulations. PTH

# 33 ELECTRONICS AND ELECTRICAL ENGINEERING

Includes test equipment and maintainability, components, e.g., tunnel diodes and transistors, microminiaturization, and integrated circuitry.

For related information see also 60 Computer Operations and Hardware and 76 Solid-State Physics

N79-14309\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

SPACE SHUTTLE ACTIVE POGO-SUPPRESSOR CONTROL DESIGN USING LINEAR QUADRATIC REGULATOR TECHNIQUES

Bruce Lehtinen and Carl F. Lorenz. Jan. 1979. 83 p. refs. (NASA-TP-1217; E-9578). Avail. NTIS. HC A05/MF A01. CSCL. 090.

Two methods of active pogo suppression (stabilization) for the space shuttle vehicle were studied analytically. The basis for both approaches was the linear quadratic regulator, state space technique. The first approach minimized root-mean-square pump inlet pressure by using either fullstate feedback, partial-state feedback, or output feedback with a Kalman filter. The second approach increased the modal damping associated with the critical structural modes by using either full-state feedback or reconstructed state feedback. A number of implementable controls were found by both approaches. The designs were analyzed with respect to sensitivity, complexity, and controller energy requirements, as well as controller performance Practical controllers resulting from the two design approaches tended to use pressure and flow as feetback variables for the minimum-rms method and structural accelerations or velocities for the modal control method. Both approaches are suitable for the design of active pogo-suppression controllers.

N79-17139\*# National Aeropautics and Space Administration. Lewis Research Center, Cleveland, Ohio

EFFICIENCY ENHANCEMENT OF OCTAVE BANDWIDTH TRAVELING WAVE TUBES BY USE OF MULTISTAGE DEPRESSED COLLECTORS

Peter Rannins and Thumas A. Fox. Feb. 1979, 29 p. refs. (NASA-TP-1418, E-9749). Avail. NTIS. HC A03/MF A01, CSCL. 09A.

Small, three and five-stage depressed collectors were evaluated in conjunction with a 4.8- to 9.6-GHz TWT of 325to 675-W power output and a beam of 0.5 microperv. The multistage depressed collector (MDC) performed well even though its design had been optimized for a TWT of identical design but considerably less output power Despite large, fixed losses significant efficiency enhancement was demonstrated with both the three- and five-stage depressed collectors. At saturated if power output, the improvement in the overall efficiency ranged from a factor of 2.5 to 3.0 for the three-stage collector and a factor of 30 to 35 for the five-stage collector. At saturation three-stage collector efficiencies of 77 to 80 percent and five-stage collector efficiencies of 81 to 84 percent were obtained across the frequency band. An overall efficiency of 37.0 to 44.3 percent across the frequency band of 4.8 to 9.6 GHz was demonstrated with the use of harmonic injection. For operation below saturation, even larger relative improvements in the overall TWT efficiency were demonstrated. Collector performance was relatively insensitive to the degree of regulation of the collector power supply

N79-20316\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

TWT DESIGN REQUIREMENTS FOR 30/20 GHz DIGITAL COMMUNICATIONS' SATELLITE

N Stankiewicz and G Anzic 1979 13 p Presented at the 17th Aerospace Sci Meeting, New Orleans, 15:17 Jan 1979, sponsored by AIAA

(NASA-TM-79119, E-9952) Avail NTIS HC A02/MF A01 CSCL 09A

The rapid growth of communication traffic (voice, data, and video) requires the development of additional frequency bands before the 1990's. The frequencies currently in use for satellite communications at 6/4 GHz are crowded and demands for 14/12 GHz systems are increasing Projections are that these bands will be filled to capacity by the late 1980's. The next higher frequency band allocated for satellite con junications is at 30/20 GHz. For interrelated reasons of efficiency, power level, and system reliability criteria, a candidate for the downlink amplifier in a 30/20 GHz communications' swellite is a dual mode traveling wave tube (TWT) equipped with a highly efficient depressed collector. A summary is given of the analyses which determine the TWT design requirements. The overall efficiency of such a tube is then inferred from a parametric study and from experimental data on multistaged depressed collectors. The expected TWT efficiency at 4 dB below output saturation is 24 percent in the high mode and 22 percent in the low mode.

N79-22375\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYTICAL PREDICTION WITH MULTIDIMENSIONAL COMPUTER PROGRAMS AND EXPERIMENTAL VERIFICATION OF THE PERFORMANCE, AT A VARIETY OF OPERATING CONDITIONS, OF TWO TRAVELING WAVE TUBES WITH DEPRESSED COLLECTORS

James A. Dayton, Jr., Henry G. Kosmahl, Peter Ramins, and Norbert Stankiewicz. May 1979. 28 p. refs. (NASA-TP-1449; E-9728). Avail. NTIS. HC A03/MF A01. CSCL

Experimental and analytical results are compared for two high performance, octave bandwidth TWTs that use depressed collectors (MDC's) to improve the efficiency. The computations were carried out with advanced, multidimensional computer programs that are described here in detail. These programs model the electron beam as a series of either disks or rings of charge and follow their multidimensional trajectories from the RF input of the ideal TWT, through the slow wave structure, through the magnetic refocusing system, to their points of impact in the depressed collector. Traveling wave tube performance, collector efficiency, and collector current distribution were computed and the results compared with measurements for a number of TWT-MDC systems. Power conservation and correct accounting of TWT and collector losses were observed For the TWT's operating at saturation, very good agreement was obtained between the computed and measured collector efficiencies. For a TWT operating 3 and 6 dB below saturation, excellent agreement between computed and measured collector efficiencies was obtained in some cases but only fair agreement in others However, deviations can largely be explained by small differences in the computed and actual spent beam energy distributions. The analytical tools used here appear to be sufficiently refined to design efficient collectors for this class of TWT. How over, for maximum efficiency, some experimental optimization (e.g., collector voltages and aperture sizes) will most likely be Author required

N79-23348\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

DESCRIPTION OF A 2.3 kW POWER TRANSFORMER FOR SPACE APPLICATIONS

Inving Hansen 1979 12 p. refs. Presented at the Aerospace High Voltage Workshop, Anaheim, Calif. 26:27 Feb. 1979, iponsored in part by Intern. Electron. Packaging Soc. Aerospace Electron. Systems. Soc. and IEEE.

(NASA-TM-79138, E-9976) Avail NTIS HC A02/MF A01 CSCL 09C

The principle features and special testing of a high voltage high power transformer designed and developed for space application are described. The transformer is operated in a series resonant inverter supplying beam power to a 30 cm mercury ion thruster Electrical requirements include operation of 2.3 kW continuous power output, primary currents to 35 amps rms, and frequencies up to 20 kHz. High efficiency was obtained through detailed considerations of the tradeoffs available in coramaterials, wire selection, coil configurations and thermal control. A number of novel heat removal techniques are discussed which

control the winding temperature using only the available conductive cooling.

N79-26316\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF A 14.9-kW LAMINATED-FRAME dc SERIES MOTOR WITH CHOPPER CONTROLLER

John R. Schwa's Jun. 1979 41 p refs Prepared for DOE (Contract EC-77 A-31-1044)

(NASA-TM-79177, DOE/NASA/1044-79/2) Avail NTIS HC A03/MF A01 CSCL 09A

Traction motor using two types of excitation: ripple free do from a motor generator set for baseline data and chopped do as supplied by a battery and chopper controller was tested. For the same average values of input voltage and current, the power output was independent of the type of excitation. At the same speeds, motor efficiency at low power output (corresponding to low duty cycle of the controller) was 5 to 10 percentage points less on chopped do than on ripple-free do. This illustrates that for chopped waveforms, it is incorrect to calculate input power as the product of average voltage and average current. Locked-rotor torque, no load losses, and magnetic saturation data were so determined.

N79-27400°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN OF HIGH-PERVEANCE CONFINED-FLOW GUNS FOR PERIODIC PERMANENT-MAGNET-FOCUSED TUBES N Stankiewicz Jun 1979 17 p refs (NASA-TP-1485 F-9729) Avail NTIS HC 402/MF 401 CSCL

(NASA-TP-1485 E 9729) Avail NTIS HC A02/MF A01 CSCL 09C

An approach to the design of high pervence, low conforeshing guns is described in which confinement is used to stabilize the beam for subsequent periodic permanent-magnet focusing. The computed results for two cases are presented. A magnetic boundary value problem was solved for the scalar potential from which the axial magnetic field was computed. A solution was found by iterating between Poisson's equation and the electron trajectory calculations. Magnetic field values were varied in magnitude until a laminar beam with minimum scalloping was produced.

N79-28420\* Nationa Aeronautics and Space Administration

EFFICIENCY ENHANCEMENT OF DUAL-MODE TRAVELING WAVE TUBES AT SATURATION AND IN THE LINEAR RANGE BY USE OF SPENT-BEAM REFOCUSING AND MULTISTAGE DEPRESSED COLLECTORS

Peter Ramins and Thomas A. Fox. Jul. 1979 26 p. refs. (NASA-TP-1486, E-9912). Avail. NTIS. HC A03/MF A01. CSCL. 09C.

An axisymmetric, multistage depressed collector of fixed geometric design was evaluated in conjunction with an oclavebandwidth dual-mode TWT. The TWT was operated over a wide range of conditions to simulate different applications. The collector was operated in three, four, and five-stage configurations, and its performance was optimized (within the constraint of fixed geometric design) over the range of TWT operating conditions covered For operation of the dual mode TWT at and near saturation the collectors increased the TWT overall efficiency by a factor of 2 1/2 to 3 1/2 Collector performance was relatively constant for both the high and low TWT modes and fer operation of the TWT across an octave bandwidth. For operation of the TWT in the linear low-distortion range, collector ef ficiencies of 90 percent and greater wern obtained, leading to a five to twelvefold increase in the TWT overall efficiency for the range of operating conditions covered and reasonably high Igreater than 25 percent) overall efficiencies well below saturation

Author

N79-31499\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYTICAL CORE LOSS CALCULATIONS FOR MAGNETIC MATERIALS USED IN HIGH FREQUENCY HIGH POWER CONVERTER APPLICATIONS Ph.O. Thesis - Toledo Univ. James E. Triner. Aug. 1979 103 p. refs.

(NASA-TM-79234, E-9993) Avail: N (IS HC AQ6/MF A01 CSCL 09A

The basic magnetic properties under various operating conditions encountered in the state of the art DCAC/DC converters are examined. Using a novel core excitation circuit, the basic B H and loss characteristics. If virtuals core materials may be observed as a function of circuit configuration, frequency of operation, input voltage, and pulse-width modulation conditions. From this empirical data, a mathematical loss characteristics equation is developed to analytically predict the specific core loss of several magnetic materials under various waveform excitation conditions.

N79 32463\* National Aeronautics a Space Administration. Lewis Research Center, Cleveland, Ohio

### MULTISTAGE DEPRESSED COL'F TOR FOR DUAL NODE OPERATION Patent Application

H. G. Kosmahl, inventor (to NASA). Fig. d. 7. Sep. 1979. 14 p. (NASA-Case-LFW 13282-1, US-Patent-Appl-SN-073579). Avail: NTIS. HC A02/MF A01. CSCL 09C.

A depressed collector which captures the spent electrons of a microwave transmitting tube at high efficiency in both high and low power modes of opera on is provided. The end electrode has a spike extending loward the entrance electrode. Intermediate electrodes and the entrance electrode have central speriures increasing in size in a downstream direction. These electrodes capture most high power mode spent electrons. A low power mode electrode is positioned between the last intermediate electrode and the end electrode to capture in power spent electrons. This electrode has a central confure presently smaller but no larger than that of the last intermediate electrode. An auxiliary low power mode electrode with a central aperture larger than that of the low power mod dectrode may be axially positioned between the end election and the low power mode electrode. The electrodes are all at voltages provided by a voltage divider connected becasen a necrtive potential and a common ground return

N79-3246?\* 

National Aeronautics and Space Administration Lewis Rese on Center, Cleveland, Chio

### OPTICALLY ISOLATED LOGARITHMIC "ANOAMMETER CAPABLE OF FLOATING TO 5 KILOVO"

John C Sturman and John C DeLaat Was ligited. Oct 1979 22 p. refs.

(NASA-TP 1527, E-9934) Avail NTIS HC A02/MF A01 CSCL 09C

A logarithmic current-measuring instrument was developed to measure plasma coupling currents at a common mode volta; e of 5 kilovolts. Positive or negative currents can be messured from 10 to the -9th power to 001 ampere direct current. Optical isolation is used to control in let witching and to provide data referenced to ground potential. Analog meter readouts as well as zero to five volt outputs are provided for peripheral data collection. Six independent channels are provided. Three measure positive currents, and three measure negative currents. Although designed for vacuum operation, it can be used equally well in air to measure low currents at high common mode voltages.

ΚL

A79-15305 \* Design study of superconducting magnets for a combustion magnetohydrodynamic /MHD/ generator. R. J. Thome, J. W. Ayers, T. M. Hrydaj (Magnetic Corporation of America, Waltham Mass.), and J. A. Buckhart (NASA, Lewis Research Center, Cleveland, Ohio). In: Advances, in cryogenic engineering. Volume 23. Proceedings of the Conference, Boulder, Colos, August 2.5, 1977. (A79-15301-04-31). New Yirk, Plenum Press, 1978, p. 28-36. Contract No. NAS3, 19865.

Results are presented to a made off and preliminary design study on concepts of a superconducting magnet system for a combustion MHD generator test facility. The main objective is to gain insight into the magnitude of the project in terms of physical characteristics and cost. The net result of a first-phase evaluation of attractive design alternatives is to concentrate subsequent efforts on (1) a racetrack coil geometry with an operating temperature of 4.2 K, (2) a racetrack coil geometry with an operating temperature of 2.0 K, and (3) a rectangular saddle coil geometry with an operating temperature of 4.2 K. All three systems are to produce 8 T, and use NbTi superconductor and iron for field enhancement. Design characteristics of the three systems are described. It is shown that the racetrack and rectangular saddle coil geometries seem most suitable for this application, the former because of its simplicity and the latter because of its efficient use of material. Advantages of the rectangular saddle over the two other systems are stressed.

S.D.

A79-10881 \* Generalized computer-aided discrete time domain modeling and analysis of dc-dc converters. F. C. Lee, R. P. Iwens, Y. Yu. (TRW Defense and Space Systems Group, Redondo Beach, Calif.), and J. E. Triner (NASA, Lewis Research Center, Cleveland, Ohio). In: Power Electronics Specialists Conference, Palo Alto, Calif., June 14-16, 1977, Record. (A79-10876-01-33) New York, Institute of Electrical and Electronics Engineers, July 1977, p. 58-69, 13 refe. Cont. act. No. NAS3-19690.

A generalized discrete time domain modeling and analysis technique is presented for all types of switching regulators using any type of duty-cycle controller, and operating in both continuous and discontinuous inductor current. State space techniques are employed to derive an equivalent nonlinear discrete time model that describes the converter exactly. The system is linearized about its equilibrium state to obtain a linear discrete time model for small signal performance evaluations, such as stability, audiosusceptibility and transient response. The analysis makes extensive use of the digital computer as an analytical tool. It is universit, exact and easy to use.

(Author)

A79-10885 Power converter design optimization. Y. Yu, F. C. Y. Let. (TRW Defense and Space Systems Group, Redondo Beach, Calif.), and J. E. Triner (NASA, Lewis Research Center, Cleveland, Ohio). In Power Electronics Specialists Conference, Palo Alto, Calif., June 14-16, 1977, Record. (A79-10876-01-33) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 104-112, 11 refs. Contract No. NAS3-19690.

Utilizing the demonstrated capability of nonlinear programming algorithms, a practical design optimization approach for power converters is established to conceive a design to meet all power-circuit performance requirements and concurrently optimize a defined juantity such as weight or losses. In addition, to facilitate a cost-effective design, the computer-aided approach provides a means to readily assess (1) the weight-efficiency tradeoff, (2) impacts of converter requirements and component characteristics on a given design, and (3) optimum power system configurations. (Author)

A79-10896 \* The solid state remote power controller - Its status, use and perspective. G. R. Sundberg (NASA, Lewis Research Center, Cleveland, Ohio) and W. W. Billings (Westinghouse Electric Corp., Aerospace Electrical Div., Lima, Ohio). In. Power Electronics Specialists Conference, Palo Alto, Calif., June 14-16, 1977, Record. (A79-10876-01-33). New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 244-253, 16 refs.

Remote power controllers (RPCs) are solid state devices that combine in one unit the capability to perform all the needed functions of load switching, overload protection and a direct indication of whether the load is on or off. They provide total system protection of equipment and wires RPCs are designed to be located near the load and communicate control and status information remotely via low level signals of a few milliwatts. The design and operation or the RPC are considered, taking into account the operation of an RPC, the RPC power switch and drive circuits, control and trip circuits, fail-safe devices, and RPC overcurrent

protection. Attention is given to the RPC development status, RPC applications, and RPC perspectives. G.R.

A79-25118 \* # Comments on measuring the overall and the depressed collector efficiency in TWT's and klystron amplifiers. H. G. Kosmahl (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices*, vol. ED-26, Feb. 1979, p. 156.

Kosmahl and Ramins (1977), who reported results achieved with broadband, high-performance TWT's, augmerized with multistage depressed collectors for higher overall efficiency, have pointed out the necessity for accurately measuring and correctly defining the various power terms involved. In view of the now vide-spread use of depressed collectors and reported results, the definitions of tube and collector efficiency are restated and comments are provided on the sensitivity of these terms to various sources of experimental and definitional errors in order to permit a uniform evaluation of collector performance.

G.B.

A79:34001 • Description of A 2.3 kW power transformer for space applications. I. Hansen (NASA, Lewis Research Center, Cleveland, Ohio). International Electronics Packaging Society Aerospace Electronic Systems Society, and IEEE, Aerospace High Voltage Workshop, Anaheim, Calif., Feb. 26, 27, 1979, Paper. 10 p.

The paper describes the principal features and special testing of a high-frequency high-power low-specific-weight (0.57 kg/kW) 2.3-kW electronic power transformer developed for space applications. The transformer is operated in a series resonant inverter supplying beam power to a 30-cm mercury ion thruster. High efficiency (above 98.5%) is obtained through careful detailed design. A number of unique heat removal techniques are discussed which control the winding temperature using only the available conductive cooling.

S.D.

A79-42024 \* Comment on the mechanism of operation of the impregnated tungsten cathode, R. Forman (NASA, Lewis Research Center, Cleveland, Ohio), Journal of Applied Physics, vol. 50, Mar. 1979, p. 1546, 1547, 9 refs

Recard Infertest Pressurements, over 20,000-30,000 h, on impregnated tringsten cathodis in tubes employing an open-type electroringum structure, show emission current degradation with time. This is in contrast to those recently published by Rittner on B-type cathodes, run in close-spaced diodes, taken some years ago. These more recent life-test results are consistent with the model suggested by Forman and disputed by Rittner that the barium coverage on an impregnated cathode is less than a monolayer for most of its life and decreases with time. (Author)

A79-49526 • r Fundamental mechanisms that influence the estimate of heat transfer to gas turbine blades. R W Graham (NASA Lewis Research Center, Fundamental Heat Transfer Section, Cleveland, Ohio). American Society of Mechanical Engineers and American Institute of Chemical Engineers, National Heat Transfer Conference, San Diego, Calif., Aug. 5-8, 1979, Paper, 11-p-32 refs.

Heat transfer problems in aircraft gas turbines required for improved prediction of turbine blade or vane gas side heat transfer are examined. Estimates of the heat transfer from the gas to vanes or rothing blades are uncertain due to the complexity of the heat transfer processes, since the gas flow is three dimensional with complex secondary viscous flow patterns that interact with the endwalls and blade surfaces. In addition upstream disturbances, stagnation flow, curvature effects and flow acceleration complicate the thermal transport mechanisms in the boundary layers. The thermal state and flow characteristics of the hot gases that enter the turbine blade row, analytical methods for calculating the gas side heat transfer to turbine blades, and flow phenomana such as stagnation, curvature effects, acceleration, secondary flows, and transition that influences local heat transfer rates are discussed. A T

A79-49535 \* # Condensation on a noncollapsing vapor hubble in a subcooled liquid. K. J. Baumeister and R. J. Simoneau (NASA, Lewis Research Center, Cleveland, Ohio). National Heat Transfer Conference, 18th, San Diego, Calif., Aug. 5-8, 1979, Paper. 15 p. 13 refs.

An experimental procedure is presented by which an estimate can be made of the condensation coefficient on a noncollapsing stationary vapor bubble in subcooled liquid nitrogen. The present experimental study utilizes film boiling from a thin wire to generate vapor bubbles which remain fixed to the wire at their base. A balance was established between the evaporation in the thin annular region along the wire and the condensation in the vapor bubbles. (Author)

N79-14325\* Textron Bell Aerospace Co., Buffalo, N. Y.
A THREE-DIMENSIONAL TURBULENT COMPRESSIBLE
FLOW MODEL FOR EJECTOR AND FLUTTED MIXERS

W. L. Rushmore and S. W. Zelazny Dec. 1978 133 p refs Sponsored by NASA (NASA-CR-159467) Avail NTIS HC A07/MF A01 CSCL

(NASA-CR-159467) Avail NTIS HC A07/MF A01 CSCL 20D

A three dimensional finite element computer code was developed to analyze ejector and axisymmetric fluted mixer systems whose flow fields are not significantly influenced by streamwise diffusion effects. A two equation turbulence model was used to make comparisons between theory and data for various flow fields which are components of the ejector system. i.e., (1) turbilent boundary layer in a duct; (2) rectangular nozzle (free jet); (3) axisymmetric nozzle (free jet); (4) hypermixing nozzle (free jet): and (5) plane wall jet. Likewise, comparisons of the code with analytical results and/or other numerical solutions were made for components of the axisymmetric fluted mixer system. These included (1) developing pipe flow: (2) developing flow in an annular pipe. (3) developing flow in an axisymmetric pipe with conical center body and no fluting and (4) developing fluted pipe flow. Finally, two demonstration cases are presente i which show the code's ability to analyze both the ejector and axisymmetric fluted mixers. Author

N79-20317\*# Hughes Aircraft Co., Culver City, Calif — Technology Support Div

### LIGHTWEIGHT MULTIPLE OUTPUT CONVERTER DEVELOPMENT

Jack J. Kisch and R. M. Martinelli. Cec. 1978, 75 p. refs. (Contract NAS3-21045)

(NASA-CR-159526, P78-683R) Avail NTIS HC A04/MF A01 CSCL 09C

A high frequency, multiple output power conditioner was developed and breadboarded using an eight-stage capacitor diode voltage multiplier to provide + 1200 Vdc, and a three-stage for -350 Vdc. In addition, two rectifier bridges were capacitively coupled to the eight-stage multiplier to obtain 0.5 and 0.65 a dc constant current outputs referenced to +1200 Vdc. Total power was 120 watts, with an overall efficiency of 85 percent at the 80 kHz operating frequency. All outputs were regulated to three percent or better, with complete short circuit protection. The power conditioner component weight and efficiency were compared to the equivalent four outputs of the 10 kHz conditioner for the 8 cm ion engine. Weight reduction for the four outputs was 557 grams, extrapolated in the same ratio to all nine outputs, it would be 1100 to 1400 grams.

N79-21273\*# Westinghouse Research and Development Center. Pittsburgh. Pa

### DEVELOPMENT AND FARRICATION OF IMPROVED POWER TRANSISTOR SWITCHES Final Report

P L Hower and C K Chu Jan 1979 86 p refs

(Contract NAS3-18916)

(NASA-CR-159524) Avail NTIS HC A05/MF A01 CSCL

A new class of high voltage power transistors was achieved by adapting present interdigitated thyristor processing techniques to the fabrication of npn Si transistors. Present devices are 2.3 cm in diameter and have V sub CEO (sus) in the range of 400 to 600V. V sub CEO (sus) = 450V devices were made with an (h sub FE)(I sub C) product of 900A at V sub CE = 2.5V. The electrical performance obtained was consistent with the predictions of an optimum design theory specifically developed for power switching transistors. The device design, wafer processing, and assembly techniques are described. Experimental measurements of the dc characteristics, forward SOA, and switching times a a included A new method of characterizing the switching performance of power transistors is proposed.

J.M.IVI

N79-25312\*# TRW Defense and Space Systems Group, Redondo Reach, Calif.

EFFECTS OF ARCING DUE TO SPACECRAFT CHARGING ON SPACECRAFT SURVIVAL Final Report, May - Nov. 1978

A Rosen, N L Sanders, J M Ellen, Jr., and G. T Inouve 14 Nov. 1978. 172 p. refs (Contract NAS3-21363)

(NASA-CR-159593, TRW-33631-6006-RU-00) Avail NTIS HC A08/MF A01 CSCL 09C

A quantitative assessment of the hazard associated with spacecraft charging and arcing on spacecraft systems is presented. A literature survey on arc discharge thresholds and characteristics was done and gaps in the data and requirements for additional experiments were identified. Calculations of coupling of arc discharges into typical spacecraft systems were made and the susceptibility of typical spacecraft to disruption by arc discharges was investigated. Design guidelines and recommended practices to reduce or eliminate the threat of malfunction and failures due to spacecraft charging/arcing were summarized. R.E.S.

N79-27397\* # Systems Science and Software, La Jolla, Calif EXTENSION, VALIDATION AND APPLICATION OF THE NASCAP CODE Final Report, 9 Sep. 1977 - 11 Jan. 1979 I Katz J J Cassidy, III, M J Mandell, G. W Schnuelle. P G Steen, D E Parks, M Rotenberg, and J H. Alexander Jan. 1979 326 p refs

(Contract NAS3-21050)

(NASA-CR-159595, SSS-R-79-3904) Avail NTIS HC A15/MF A01 CSCL 09C

Numerous extensions were made in the NASCAP code. They fall into three categories: a greater range of definable objects, a more sophisticated computational model, and simplified code structure and usage. An important validation of NASCAP was performed using a new two dimensional computer code (TWOD). An interactive code (MATCHG) was written to compare material parameter inputs with charging results. The first major application of NASCAP was performed on the SCATHA satellite. Shadowing and charging calculation were completed. NASCAP was installed at the Air Force Geophysics Laboratory, where researchers plan to use if to interpret SCATHA data.

N79-27398\*# Systems Science and Software La Jolla, Calif NASCAP USER'S MANUAL, 1978 Contractor Report, Sep. 1977 - Sep. 1978

J J Cassidy III Aug 1978 257 p refs (Contract NAS3 21050)

(NASA-CR-159417 SSS R-78-3739) Avail NTI: HC A12/MF A01 CSCL 09C

NASCAP simulates the charging process for a complex object in either tenuous plasma (geosynchronous orbit) or ground tost (electron gun source) environment. Program control words, the structure of user input files, and various user options available are described in this computer programmer's user minual R.E.S.

N79-28418\* Science Applications, Inc., Vienna, Va Radiation and Electromagnetics Div

FIRST PRINCIPLES NUMERICAL MODEL OF AVALANCHE-INDUCED ARC DISCHARGES IN ELECTRON-IRRADIATED DIELECTRICS Final Report, Jul. 1978 - Feb. 1979

B. L. Beers, V. W. Pirie, H. C. Hwang, H. W. Bloomberg, D. L. Lin, M. J. Schmidt, and D. J. Strickland. Mar. 1979, 203 p. refs.

(Contract NAS3-21378)

(NASA CR-159560, SAI-102-79-002) Avail NTIS HC A10/MF A01 CSCL 09C

The model consists of four phases single electron dynamics, single electron avalanche, negative streamer development, and tree formation. Numerical algorithms and computer code implementations are presented for the first three phases. An approach to developing a code description of fourth phase is discussed. Numerical results are presented for a crude material model of Teflon.

Author.

A79-10880 \* A general unified approach to modelling switching dc-to-dc converters in discontinuous conduction mode. S. Cuk and R. D. Middlebrook (California Institute of Technology, Pasadena, Calif.). In: Power Electronics Specialists Conference, Palo Alto, Calif., June 14-16, 1977, Record. (A79-10876-01-33) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 36-57, 13 refs. Contracts No. NAS3-19690, No. NAS3-20102, No. MIPR-N-0095377MP09018.

A method for modelling switching converters in the discontinuous conduction mode is developed, whose starting point is the unified state-space representation, and whose end result is a complete linear circuit model which correctly represents all essential features, namely, the input, output, and transfer properties (static do as well as dynamic ac small signal). While the method is generally applicable to any switching converter operating in the discontinuous conduction mode, it is extensively illustrated for the three common power stages (buck, boost, and buck-boost). The results for these converters are then easily tabulated owing to the fixed equivalent circuit topology of their canonical circuit model. (Author)

A79-10888 \* A new optimum topology switching dc-to-dc converter. S. Cuk and R. D. Middlebrook (California Institute of Technology, Pasadena, Calif.). In: Power Electronics Specialists Conference, Palo Alto, Calif., June 14-16, 1977, Record. (A79-10876-01-33). New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 160-179. 10 refs. Contracts No. NAS3-19690; No. NAS3-20102, No. MIPR-N-0095377MP09018.

A novel switching do-to-do converter is presented, which has the same general conversion property (increase or decrease of the input do voltage) as does the conventional buck-boost converter, and which offers through its new optimum topology higher efficiency, lower output voltage ripple, reduced EMI, smaller size and weight, and excellent dynamic response. One of its most significant advantages is that both input and output current are not pulsating but are continuous (essentially do with small superimposed switching current ripple), thus resulting in a close approximation to the ideal physically nonrealizable do-to-do transformer. The converter retains the simplest possible structure with the minimum number of components which, when interconnected in its optimum topology, yield the maximum performance. (Author)

A79-48653 \* Input filter design for switching regulators. F. C. Lee (Virginia Polytechnic Institute and State University, Blacksburg, Va.) and Y. Yu (TRW Detense and Space Systems Group, Redondo Beacli, Calif.). In: NAECON 1979. Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 15-17, 1979. Volume 2. (A79-48590 21-01) New York, Institute of Electrical and Electronics Engineers, Inc., 1979, p. 704-711, 7 refs. Contract No. NAS3-20102.

A small signal average model is derived to study analytically the complex interaction among iriput filter, output fill r and control loop, which frequently causes degradation of switch regulator

performance. Analytically based design guidelines are formulated, and key design parameters are identified. It is shown that minimization of the forward transfer characteristics and the output impedance of the input filter at filter resonance are key to designing an input filter for a switching regulator with given output filter parameters and specified line and load conditions.

V.P.

A79-49397 \* Analysis of a parallel-arrayed power regulating system. 3. K. Colburn (Texas A & M University, College Station, Tex.), H. M. Horton (M & S Computing, Inc., Huntsville, Ala.), and M. A. Honnell (Auburn University, Auburn, Ala.). IEEE Transactions on Industrial Electronics and Control Instrumentation, vol. IECI-26, Aug. 1979, p. 134-141, 9 refs. Contract No. NASB-26752.

A power regulation system incorporating n-parallel power supplies employing PWM switching regulators is studied. Analysis of indiv.dual unit operation and coupled-system parameter sensitivity is considered from an operations viewpoint. A detailed example is included to illustrate parallel system operation for 18 such units powered by solar-cell banks.

(Author)

A79-49398 \* Modeling of switching regulator power stages with and without zero-inductor-current dwell time. F. C. Y. Lee (Virginia Polytechnic Institute and State University, Blacksburg, Va.) and Y. Yu (TRW Defense and Space Systems Group, Redondo Beach, Calif.). IEEE Transactions on Industrial Electronics and Control Instrumentation, vol. IECI-26, Aug. 1979, p. 142-150. 10 refs. Contract No. NAS3:1960.

State-space techniques are amployed to derive accurate models for the three basic switching converter power stages: buck, boost, and buck/boost operating with and without zero-inductor-current dwell time. A generalized procedure is developed which treats the continuous inductor-current mode without dwell time as a special case of the discontinuous-current mode when the dwell time vanishes. Abrupt changes of system behavior, including a reduction of the system order when the dwell time appears, are shown both analytically and experimentally. Merits resulting from the present modeling technique in comparison with existing modeling techniques are illustrated.

(Author)

### 34 FLUID MECHANICS AND HEAT TRANSFER

Includes boundary layers, hydrodynamics, fiuidics, mass transfer, and ablation cooling.

For related information see also 02 Aerodynamics and 77 Thermodynamics and Statistical Physics

N79-10339\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

#### TRAVELING WAVE TUBE CIRCUIT Patent

Denis J. Connolly, inventor (to NASA) issued 3 Oct 1978 4 p Filed 15 Feb 1977 Supersedes N77-17360 (15 - 08. p 1025)

(NASA-Case-LEW-12013-1, US-Patent-4,118.671, US-Patent-Appl-SN-768795, US-Patent-Class-330-42,

US-Patent-Class-315-35. US-Patent-Class-315-36.

US-Patent-Class-301-82) Avail US Patent Office CSCL 09A

A traveling wave tube (TWT) has a slow wave structure (SWS) which is severed into two or more sections. A signal path, connects the end of an SWS section to the beginning of the following SWS section. The signal path comprises an impedance matching coupler (IMC), followed by an isolator, a variable phase shifter, and a second IMC. The aggregate band pass characteristic of the components in the signal path is chosen to reject, or strongly attenuate, all frequencies outside the desired operating frequency range of the TWT and yet pass, with minimal attenuation in the forward direction, all frequencies within the desired operating frequency range. The isolator is chosen to reject. or strongly attenuate, waves, of all frequencies, which propagate in the backward direction. The aggregate phase shift characteristic of the components in the signal path is chosen to apply signal power to the beginning of the following SWS section with the phase angle yielding maximum efficiency

Official Gazette of the U.S. Patent Office

N79-12361\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

#### DECAY OF HOMOGENEOUS TURBULENCE FROM A GIVEN STATE AT HIGHER REYNOLDS NUMBER

R G Deissler Nov 1978 15 p refs. Presented at the 31st Ann Meeting of the Am. Phys Soc Div of Fluid Dyn. Los Angeles, 19-21 Nov 1978

(NASA-TM-79011, E-9796) Avail NTIS HC A02/MF A01 CSCL 20D

The turbulence equations are closed by specification of initial conditions (using either a Taylor or an exponential series) and by a modified Kovasznay-type closure. Good results for large times are obtained only for the initial-conditions closure used with four or more terms of an exponential series. The evolution. of all of the initially specified spectra can be calculated rather well from the theory. From a fundamental standpoint the method thus seems to be satisfactory Author

N79-12362°# National Aerona Lics and Space Administration Lewis Research Center, Cicveland, Ohio

#### ATOMIZATION OF WATER JETS AND SHEETS IN AXIAL AND SWIRLING AIRFLOWS

Robert D Ingebo [1977] 12 p refs Proposed for presentation at the 24th Ann Intern Gas furbine Conf. San Diego, Calif 11-15 Mar 1979, sponsored by the Am. Soc of Mech Engr (NASA-TM-79043, E-9847) Avail NTIS HC A02/MF A01 CSCL 20D

Axial and swirling airflows were used to break up water jets and sheets into sprays of droplets to determine the overall effects of orifice diameter, weight flow of air, and the use of an air swirler on fineness of atomization as characterized by mean drop size. A scanning radiometer was used to determine the mean drop diameter of each spray. Swirling airflows were produced with an axial combustor, 70 deg blake angle, air swiring Water jets were injected axially upstream axially downstream and cross stream into the airflow. In addition, pressure atomizing fuel nozzles which produced a sheet and ligament type of breekup were investigated. Increasing the weight flow rate of air or the use of an air swirling markedly reduced the spray mean drop size

N79-13288\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

#### HEAT EXCHANGER Petent

Daniel E. Sokolowski, inventor (to NASA) Issued 22 Aug. 1978 6 p Filed 19 Mar 1975 Supersedes N75-19579 (13 - 11,

NASA-Case LEW-12252-1; US-Patent-4,107,919.

US-Patent-Appl-SN-559847, US-Patent-Class-165-169.

US-Patent-Class-60-267. US-Patent-Class-239-127.1) Avail US Patent and Trademark Office CSCL 20D

A heat exchanger, as exemplified by a rocket combustion chamber, is constructed by stacking thin metal rings having microsized openings therein at selective locations to form cooling passages defined by an inner wall, an outer wall and fins. Suitable manifolds are provided at each end of the rocket chamber. In addition to the cooling channel openings, coolant feed openings may be formed in each of rings. The conlant feed openings may be nested or positioned within generally U-shaped cooling channel openings. Compression on the stacked rings may be maintained by welds or the like or by bolts extending through the stacked rings.

Official Gazette of the U.S. Patent and Trademark Office

N79-13289\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HEAT EXCHANGER AND METHOD OF MAKING Patent Anthony Fortini and John M. Kazaroff, inventors (to NASA). Issued 22 Aug 1978 5 p Filed 19 Mar 1975 Supersedes N75 19580 (13 - 11, p 1244)

(NASA-Case-LEW-12441-1, US-Patent-4,108,241,

US-Patent-Appl-SN-559846, US-Patent-Class-165-146,

US-Patent-Class-165-169, US-Patent-Class-60-267,

US Patent Class 239-127 1) Avail US Patent and Trademark Office CSCL 20D

A heat exchanger of increased effectiveness is disclosed A porous metal matrix is disposed in a metal chamber or between walls through which a heat-transfer fluid is directed. The porous metal matrix has internal bonds and is bonded to the chamber in order to remove all thermal contact resistance within the composite structure. Utilization of the invention in a rocket chamber is disclosed as a specific use. Also disclosed is a method of constructing the heat exchanger

Official Gazette of the U.S. Patent and Trademark Office

N79-15267\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### SOME HEAT TRANSFER AND HYDRODYNAMIC PROB LEMS ASSOCIATED WITH SUPERCONDUCTING CABLES (SPTL)

Robert C. Hendricks, David E. Daney (NBS, Boulder, Colo.), V. M Yeroshenko (Krzhizhanovsky Power Inst. Moscow). Ye V Kuznetsov (Krzhizhanovsky Power Inst. Moscow) and O. A. Shevckenko (Krzhizhanovsky Power Inst. Mosow) 1978 28 p. refs. Presented at the US USSH Comm. for Superconducting Power Transmission, Upton, N. Y., 5.6 oct. 1978. (NASA TM 79023 DOE/NASA/0207-78/1) Avail NTIS

HC A03/MF A01 CSCL 20D

To study some effects of thermogravitation on (CIIK SPTL) systems, a heated tube experiment was set up at Krzhizhanovsky Power Engineering Institute Moscow, U.S.S.R. Heat transfer data were taken with fluid helium flowing through a 2.85 m. 19 mm diameter uniformly heated horizontal tube. Temperatures were measured on the top and bottom of the tube at six axial locations with three other circumferential measurements made at (X/L) = 57 Typical temperature profiles show significant variations both axially and circumferentially. The data are grouped using reduced Nusselt number (NuR) and the bulk expansion parameter for each axial location. The average data for 0.26 less than or equal to X/L less than or equal to 0.76 follow a power law relation with the average expansion parameter

System instabilities are noted and discussed. Future work including heat transfer in coaxial cylinders is discussed. Author

N79-18288\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

# TACT 1: A COMPUTER PROGRAM FOR THE TRANSIENT THERMAL ANALYSIS OF A COOLED TURBINE BLADE OR VANE EQUIPPED WITH A COOLANT INSERT. 2. PROGRAMMERS MANUAL

Raymond E. Gaugler Jan. 1979, 164 p. refs. (NASA-TP-1391, E-9767). Avail. NTIS. HC A08/MF A01. CSCL. 20D.

A computer program to calculate transient and steady state temperatures, pressures, and coolant flows in a cooled axial flow turbine blade or vane with an impingement insert is described Coolant-side heat transfer coefficients are calculated internally in the program, with the user specifying either impingement or convection heat transfer at each internal flow station. Spent impingement air flows in a chordwise direction and is discharged through the trailing edge and through film cooling holes. The ability of the program to handle film cooling is limited by the internal flow model. Input to the program includes a description of the blade geometry, coolant-supply conditions, outside thermal boundary conditions, and wheel speed. The blade wall can have two layers of different materials, such as a ceramic thermal barrier coating over a metallic substrate. Program output includes the temperature at each node, the coolant pressures and flow rates, and the coolant-side heat transfer coefficients

**N78-20341\*** 
# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

### FLOW FRICTION OF THE TURBULENT COOLANT FLGW IN CRYCGENIC POROUS CABLES

Robert C. Hendricks, V. M. Yeroshenko (Krzhizhanovsky Power Eng Inst.), L. I. Zaichik (Krzhizhanovsky Power Eng Inst.), and L. S. Yanovsky (Krzhizhanovsky Power Eng Inst.), 1979—18 prefs. Proposed for presentation at the 15th Intern. Congr. on Refrigeration, Venice, 23-29 Sep. 1979, sponsored by Intern. Inst. of Refrigeration. Prepared for DOE.

(NASA-TM-79052, DOE/NASA/0207-79/1) Avail NTIS HC A02/MF A01 CSCL 20D

Considered are cryogenic power transmission cables with porous cores Calculations of the turbulent coolant flow with injection or suction through the porous wall are presented within the framework of a two-layer model. Universal velocity profiles were obtained for the viscous sublayer and flow core. Integrating the velocity profile, the law of flow friction in the pipe with injection has been derived for the case when there is a tangential injection velocity component. The effect of tangential velocity on the relative law of flow friction is analyzed. The applicability of the Prandtl model to the problem under study is discussed It is shown that the error due to the acceptance of the model increases with the injection parameter and at lower Reynolds numbers, under these circumstances, the influence of convective terms in the turbulent energy equation on the mechanism of Author turbulent transport should be taken into account

N79-20336\* National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio:

#### CLOSED LOOP SPRAY COOLING APPARATUS Patent

Donald L Alger, William B Schwab, and Edward R Furman inventors (to NASA). Issued 27: Feb: 1979; 4: p. Filed 31: Aug. 1977. Supersedes N?7-32434 (15 - 23, p. 3075). Division of US Patent Appl. SN-672220, filed 31: Mar. 1976. US-Patent 4, 068:495.

(NASA-Case-LEW-11981-2, US-Patent-4,141,22-4

US Patent Appl SN 829315. US Patent Class 32-514R

US Patent Class 62 268 US Patent Class 62 376

US-Patent Class-313-32, US-Patent-Class-313-32, US-Patent-Class-313-35, US-Patent-Appl SN 672220

US Patent 4.068 495) Avail US Patent and Trademark Office CSCL 20D

A closed loop apparatus for jet spraying coolant against the back of a radiation target is described. The coolant is circulated.

through a closed loop with a bubble of inert gas being maintained around the spray. Mean material is disposed between the bubble and the surface of the liquid coolant which is below the bubble at a predetermined level. In a second arrangement no inert gas is used, the bubble consists of vapor produced when the coolant is sprayed against the taiget.

Official Gazette of the U.S. Patent and Trademark Office

N79-20337\*# National Aeronautics and Space Administration.
Lewis Research Center. Cleveland, Ohio

### SOME EFFECTS OF CYCLIC INDUCED DEFORMATION IN ROCKET THRUST CHAMBERS

N. P. Hannum and R. J. Quentmeyer. 1979. 15 p. refs. To be presented at the Conf. on Advanced Technol. for Future Space Systems, Hampton, Va., 8-11. May. 1979. sponsored by AIAA. (NASA-TM-79112, E-9939). Avail. NTIS. HC A02/MF A01. CSCI. 20D.

A test program to investigate the deformation process observed in the hot gas wall of rocket thrust chambers was conducted using three different liner materials. Five thrust chambers were cycled to failure using hydrogen and caygen as propellants at a chamber pressure of 4.14 MN/m squre (600 psia). The deformation was observed nondestructively at middle points and destructively after failure occurred. The cyclic life results are presented with an accompanying discursion about the types of failure encountered. Data indicating the deformation of the thrust chamber liner as cycles are accumulated are presented for each of the test thrust chambers.

Author

N79-20338\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

### ON THE EQUIVALENCE BETWEEN SEMIEMPIRICAL FRACTURE ANALYSES AND R-CURVES

Thomas W Orange 1979 34 p. refs. Presented at the 12th Natl Symp. on Fracture Nech., St. Louis, 21-23 May 1978; sponsored by the Am. Soc. For Testing Water.

(NASA-TM-79127, E-9963). Avail NTIS HC A03/MF A01 CSCL 20D

The relationship between several semiempirical fracture analyses (SEFA) and the R-curve concept of fracture mechanics is examined. The conditions for equivalence between a SEFA and an R-curve are derived A hypothetical material is employed to study the relationship analytically. Equivalent R-curves are developed for real materials using data from the literature. For each SEFA there is an equivalent R-curve whose magnitude and shape are determined by the SEFA formulation and its empirical parameters of the R-curve is indeed unique then the various empirical parameters cannot be constant, and vice versal However, for one SEFA the differences are small enough that they may be within the range of normal data scatter fur real parameters.

N79 20346\* National Aeronautics and Space Administration Lawis Research Center Cleveland, Ohio

#### FUNDAMENTAL MECHANISMS THAT INFLUENCE THE ESTIMATE OF HEAT TRANSFER TO GAS TURBINE BLADES

R W Graham 1979 13 p. refs. To be presented at the Natl Heat Transfer Conf., San Diego, Calif. 5-8 Aug. 1979, cosponsored by ASME and the Am. Inst. of Chem. Engr.

(NASA TM 79128 E 9966) Avail NTIS HC A02/MF A01 CSCL 21E

Estimates of the heat transfer from the gas to stationary (vanes) or rotating blades poses a major uncertainty due to the complexity of the heat transfer processes. The gas flow through these blade rows is three dimensional with complex shoondary viscous flow patterns that interact with the endwalls and blade surfaces. In addition, upstream disturbances, stagnation flow curvature effects, and flow acceleration complicate the thermal transport mechanisms in the boundary layers. Some of these fundamental heat transfer effects are discussed. The chief purpose of the discussion is to acquaint those in the heat transfer community not directly involved in gesturbines of the seriousness.

of the problem and to recommend some basic research that would improve the capability for predicting gas-side heat transfer on urbine blades and vanes.

N79-21313\*# National Aeronautics and Space Administration. Lewis Research Center, Claveland, Ohio.

## A HEAT EXCHANGER AND / TETHOD OF MAKING Patent Application

A. Fortini and John M. Kazaroff, inventors (to NASA). Filed 30 Nov. 1977, 14 p.

(NASA Case-LEW-12441-2, US Patent-Appl-SN-856462) Avail. NTIS HC A02/MF A01 CSCL 20D

A heat exchanger of increased effectiveness is described. A porous metal matrix is disposed in a metal chamber or between walls through which a heat-transfer fluid is directed. The porous metal matrix has internal bonds and is bonded to the chamber in order to remove all thermal contact resistance within the composite structure. A specific use is to provide a method of making a rocket chamber with maximum heat transfer at the throat area where inner wall temperatures are the highest.

NASA

N79-22415\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## INTRODUCTION: THERMAL RADIATION IN INDUSTRIAL FLAMES

R Siegel In Von Karman Inst for Fluid Dyn Thermal Radiation in Ind Flames 1971 72 p refs (For primary document see N79 22413 13:34)

Avail NTIS HC A14/MF A01 CSCL 20D

The following topics are addressed: (1) emissive characteristics of a blackbody: (2) definition of properties for nonblack surfaces. (3) fundamentals of radiation in absorbing, emitting, and scattering media. (4) radiation in the presence of other modes of energy transfer, and (5) propagation in isotropic medium (the complex refractive index).

N79-22426\*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

## TITANIUM ALLOY, METALLIC-FLUID HEAT PIPES FOR SPACE SERVICE

James F Morris Mar 1979 15 p refs (NASA TM 79132, E 9974) Avail NTIS HC A02/MF A01

Reactivities of titanium limit its long-term terrestrial use for unprotected heat-pipe envelopes to about 870 K (1100 F). But this external thermochemical limitation disappears when considerations shift to space applications. In such hard-vacuum utiliz titor much higher operating temperatures are possible. Primary restrictions in space environment result from vaporization, thermal creep, and internal compatibilities. Unfortunately, a respected head pipe reference indicates that titanium is compatible only with cesium from the alkali metal working fluid family. This problem and others are subjects of the present paper which advocates titanium alloy, metallic-fluid heat ries for long-lived, weight effective space service between 500 and 1300 K (440 and 1880 F).

N79-22427\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

## REVIEW AND STATUS OF LIQUID COOLING TECHNOLOGY FOR GAS TURBINES

G James VanFossen, .ir. and Francis S Stepka. Washington Apr. 1979. 31 p. refs.

(NASA TP-1038 E 9517 AVFADCOM TR-78-21) Avail NTIS HC A03: MF A01. CSCI. 20D

A review was conducted of liquid-cooled turbine technology. Selected liquid-cooled systems and methods are presented along with an assessment of the current technology status and requirements. A comprehensive bibliography is presented Author

N79-233F3\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

## A HEAT EXCHANGER AND METHOD OF MAKING Patent Application

A. Fortini and John M Kazaroff, inventors (to NASA) Filed 23 Apr. 1979 14 p

(NASA-Case-LEW-12441-3; US-Patent-Appl-SN-032307) Avail. NTIS\_HC A02/N:F A01\_CSCL 20D

A heat exchanger of increased effectiveness is disclosed A porous metal matrix is disposed in a metal chamber or between wills through which a heat-transfer fluid is directed. The porous metal matrix has internal bonds and is bonded to the chamber in order to remove all thermal contact resistance within the composite structure. Utilization of the invention in a rocket chamber is disclosed as a specific use. Also disclosed is a method of constructing the heat exchanger.

NASA

N79-23384\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### MEASUREMENTS OF MIXED CONVECTIVE HEAT TRANS-FER TO LOW TEMPERATURE HELIUM IN A HORIZONTAL CHANNEL

V. M. Yeroshenko (Krzhizhanovsky Power Eng. Inst.), Ye. V. Kuznetsov (Krzhizhanovsky Power Eng. Inst.), O. A. Shevchenko (Krzhizhanovsky Power Eng. Inst.), Robert C. Hendricks, and D. E. Daney (NBS, Boulder, Colo.). 1979. 16 p. refs. Proposed for presentation at the 15th Intern. Congr. on Refrigeration, Venice, 23-29. Sep. 1979, sponsored in part by the Intern. Inst. of Refrigeration. Sponsored by NASA. Prepared for DOE.

(NASA-TM-79158, DOE/NASA/0207-79/3, E-014) Avail NTIS HC A02/MF A01 CSCL 20D

A horizontal 2.85 m long, 19 mm id stainless steel heated circular channel was employed to measure coefficients of heat transfer to low temperature helium flow. Experimental parameters range from 5.5 to 15 K, from 0.12 to 0.3 MPa at heat fluxes up to 1000 W/m square and Reynolds numbers from 9,000 to 20,000. A significantly nonuniform distribution of heat transfer coefficients over the tube periphery is observed. Difference between temperatures on the upper and lower surfaces of the stainless steel channel wall was found to reach 9 K. It was noted that the highest temperature on the wall outer surface is displaced from its uppermost point. Measurements of local flow temperatures revealed vortical structure of the flow. The displacement of the point with the highest temperature is attributable to the effect of vortices. The relationships for calculating local and averaged coefficients of heat transfer are proposed

N79-27460\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SOME FLOW CHARACTERISTICS OF CONVENTIONAL AND TAPERED HIGH PRESURE DROP SIMULATED SEALS R. C. Hendricks. 1979. 18 p. refs. To be presented at the Joint Lubrication Conf. Dayton, Ohio. 16-18 Oct. 1979. sponsored by Am. Soc. of Lubrication Engr. and ASME.

(NASA TM-79192 E-064) Avail NTIS HC A02/MF A01 CSCL 20D

The leak rates through shaft seals with large pressure drops were simulated using gaseous hydrogen, or nitrogen flowing through an annulus with a nonrotating centerbody. The flows were choked For concentric or eccentric position of the rotor and parallel or convergent tapered flow passages, data and analysis revealed that mass flux or leak rate can be determined from a relation whose normalizing parameters depend on the thermodynamic critical constants of the working fluid and an average flow area expressed in terms of the inlet and exit cross sectional areas. Using these normalized relations the flow data for parallel and three convergent tapered shaft seal configurations are in good agreement. Generalization to any simple gas or gas mixture is implied and demonstrated.

Author

N79-27461\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

#### CONDENSATION ON A NONCOLLAPSING VAPOR SUBBLE IN A SUBCOOLED LIQUID

Kerineth J Baumeister and Robert J Simoneau 1979 17 p refs Prepared for 18th Natl Heat Transfer Conf. San Diego. Calif. 5 8 Aug. 1979 (NASA-TM-79212, E-098) Avail MTIS HC A02/MF A01 CSCL

200

An experimental procedure is presented by which an estimate can be made of the condensation coefficient on a noncollapsing stationary vapor bubble in subcooled liquid nitrogen. Film boiling from a thin wire was used to generate vapor bubbles which remain fixed to the wire at their base. A balance was established between the evaporation in the thin annular region along the wire and the condensation in the vapor bubbles JMS

N79-29467\* Mational Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

#### CONTOURED TANK OUTLETS FOR DRAINING OF CYLIN DRICAL TANKS IN LOW-GRAVITY ENVIRONMENT

Eugene P Symons Jul 1979 45 p

(NASA TP-1492 E-9969) Avail NTIS HC A03/MF A01 CSCL

An analysis is presented for defining the outlet contour of a homispherical-bottomed cylindrical tank that will prevent vapor ingestion when the tank is drained. The analysis was used to design two small-scale tanks that were fabricated and then tested in a low gravity environment. The draining performance of the tanks was compared with that for a tank with a conventional outlet having a constant circular cross-sectional area, under identical conditions. Even when drained at off-design conditions. the contoured tank had less liquid residuals at vapor ingestion than the conventional outlet tank. Effects of outflow rate. gravitational environment, and fluid properties on the outlet contour are discussed. Two potential applications of outlet K L contouring are also presented and discussed

N79-29468\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

#### TWO PHASE CHOKED FLOW OF CRYOGENIC FLUIDS IN CONVERGING DIVERGING NOZZLES

Robert J Simoneau and Robert C Hendricks Jul 1979 83 p.

INASA TP 1484 E 96591 Avail NTIS HC A05/MF A01 CSCL 20D

Data are presented for the two phase choked flow of three cryogenic fluids nitrogen methane and hydrogen in four converging-diverging nozzles. The data cover a range of inlet stagnation conditions all single phase from well below to well above the thermodynamic critical conditions in almost all cases the nozzle throat conditions were two phase. The results indicate that the choked flow rates were not very sensitive to nozzle geometry. However the axial passure profiles, especially the throat pressure and the point of vapo-ization were very sensitive to both nozzle geometry and operating conditions. A modified Henry-Fauske model correlated all the choked flow rate data to within - or : 10 percent. Neither the equilibrium model nor the Henry Fauske model predicted throat pressures well over the whole range of data. Above the thermodynamic critical temperature the homogeneous equilibrium model was preferred for both flow rate and pressure ratio. The data of the three fluids could be normalized by the principle of corresponding states

N79-30616\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### APPLICATION OF THE PRINCIPLE OF SIMILARITY FLUID MECHANICS

R C Hendericks and I V Sengers (Md Univ College Park) 1979 49 p refs.

NASA TM 79258 E 170 Avail NTIS HC A03/MF A01 CSCL

The principle of similarity applied to fluid mechanics is described and illustrated. The concept of transforming the conservation equations by combining similarity principles for thermophysical properties with those for fluid flow is examined The usefulness of the procedure is illustrated by applying such a transformation to calculate two phase critical mass flow through a nozzie

179-30516\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

### DESCRIPTION AND ORBIT DATA OF VARIABLE CONDUCTANCE HEAT-PIPE SYSTEM FOR THE COM-MUNICATIONS TECHNOLOGY SATELLITE

Louis Gedeon Aug 1979 23 p refs

(NASA-TP-1465, E-9880) A (a) NTIS HC A02/MF A01 CSCL 200

A variable-conductance heat-pipe system (VCHPS) with methanol as the working fluid and a nitrogen and helium mixture as the control gas was used for the thermal control of a 200 W RF traveling wave tube of the Communication Technology Satellite Three tainless steel heat pipes (one redundant) and an aluminum radiator were designed to transfer 196 watts for an evaporator temperature of 50 C. The system has operated for three years with no noticeable change in performance. On four occasions the heat pipes apparently deprimed. A short time after reducing the tube power, the heat pipes reprimed and the system continued to operate normally. The description, qualification testing, and orbit date of the VCHPS are presented

N79-31526°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### FREE JET PHENOMENA IN A 90 DEGREE SHARP EDGE INLET GEOMETRY

R C Hendricks 1979 30 p refs. Presented at Intern. Cryogenic Engr Conf and the Intern Cryoganic Materials Conf. Madison Wis 21 24 Aug 1979 sponsored by NBS

INASA TM 79229 E-1311 Avail NTIS HC A03/MF AU1 CSCL 20D

Under certain conditions, inlets with a sharp edge or geometric corner were shown to exhibit sufficiently strong separation effects to permit the working fluid to flow through the duct as if it were a free jet. Mass limiting flow data and associated pressure profiles for tubes of 53 64 73 and 105 length/diameter with a 90 deg sharp edge or orifice type inlet were taken and compared to Borda type inlet data to determine bounds of the free jet phenomena. For smooth tubes the limits appear to be one dimensional and dependent only on inlet stagnation conditions Similar free jet effects were found for fluid hydrogen indicating that fluid jetting may common to all fluids flowing through 90 deg sharp edge inlet geometries

N79-31527°# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

A REDUCED VOLUMETRIC EXPANSION FACTOR PLOT R C Elendricks 1979 29 p. infs. Presented it Cryogenic Engr Conl and the Intern Cryogenic Materials Conf Madison Wis 21-24 Aug 1979

NASA TM 79240 E 148) Avail NTIS HC A03 MF A01 CSCL

A reduced volumetric expansion factor plot was constructed for simple fluids which is suitable for engineering computations in hest transfer. Volumetric expansion factors were found useful in correlating heat transfer data over a wide range of operating conditions including liquids, gases and the near critical region

A79 . . . 2 . # Decay of homogeneous turbulence from a given a conat higher Rzynolds number. R. G. Deisslei (NASA, Lewis Research Center, Cleveland, Ohio. American Physical Society Annual Meeting, 31st, Los Angeles, Calif. Nov. 19.21. 1978, Paper, 14 p. B refs.

The turbulence equations are closed by specification of initial conditions (using either a Taylor or an exponential series) and by a modified Kovasznay type clusure. Good results for large-times are obtained only for the initial conditions closure used with four or more terms of an exponential series. The evolution of all of the initially specified spectra can be calculated rather well from the theory. From a fundamental standpoint the method thus seems to be satisfactory.

(Author)

A79-22424 \* Comparison of a correlation term-discard closure for decaying homogeneous turbulence with experiment. R. G. Deissler (NASA, Lewis Research Center, Claveland, Ohio). *Physics of Fluids*, vol. 22, Jan. 1979, p. 185, 186, 11 refs.

Turbulence decay is calculated by using experimental initial conditions and discarding quadruple-correlation terms in the correlation equations. Agreement with experiment is good only for moderately small times, but there are no perceptible negative spectral energies even at large times. (Author)

A79.30556 \* Atomization of water jets and sheets in axial and swirling airflows. R. D. Ingebo (NASA, Lewis Research Center, Claveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12.15, 1979. Pager 79 GT 170, 10 p.

Axial and swirling airflows were used to break up water jets and sheets into sprays of droplets to determine the overall effects of orifice diameter, weight flow of air, and the use of an air swirler on fineness of atomization as characterized by mean drop size. A scanning radiometer was used to determine the mean drop diameter of each spray. Swirling airflows were produced with an axial combustor. 70 deg blake angle, air swirling. Water jets were injected axially upstream, axially downstream and cross stream into the airflow. In addition, pressure atomizing fuel nozzles which produced a sheet and ligament type of breakup were investigated. Increasing the weight flow rate of air or the use of an air swirling markedly reduced the spray mean drop size. Test conditions included a water flow rule of 68.0 liter per hour and airflow rates (per un area) of 3.7 to 25.7 g per square cm per sec, at 293 K and inlet air static pressures of 1.01 x 10 to the 5th to 1.90 x 10 to the 5th N/sq m. (Author)

A79 37140 \* Scattering and distortion of the unsteady motion on transversally sheared mean flows. M. E. Goldstein (NASA, Lewis Research Center, Cleveland, Ohio). Journal of Fluid Mechanics, vol. 91, Apr. 27, 1979, p. 601 632, 20 refs.

It is shown that the pressure and velocity fluctuations of the unsteady motion on a transversely sheared mean flow can be expressed entirely in terms of the derivatives of two potential functions. One of these is a convenied quantity that can be specified as a boundary condition and in related to a fransverse component of the upstream velocity field. The other can be determined by solving art innomogeneous wave equation whose source term is also a connected quantity that can be specified as a boundary condition in any given problem. The general theory is used to study the resistion of an unsteady flow with a semi-infinite plate embedded a shear layer. The acoustic field produced by this interaction is calculated in the limits of low and high frequency. The results are compared with experimental one third octave sound pressure level. adiation patterns. The agreement is found to be excellent expensity. in the low frequency range, where the mean flow and convective effects are shown to have a strong influence on the direct vity of the r Author E

A79.45463.\* Turbulence generated by the interaction of entropy fluctuations with non-uniform mean flows. M. J. Goodstein INASA, Lewis Research Center Cleveland, Ohio.) Journal of Fluid Mechanics, vol. 93, July 26, 1979, p. 209-224, 20 rets.

The turbulence generated by random entropy fluctuations in an accelerating stream is analyzed. The results are obtained by using rapid distort in theory bigethick with a high frequency solution of a previously developed wave equation of a governs the small amplitude unsteady vortical and entropic historic in steady potential flows (Goldstein, 1978). Simple insults are obtained for the case of

symmetric contraction, expansion or combination of the two. It is shown that the energy of the entropy-generated turbulence increases more rapidly with the contraction ratio of a subsonic flow than that of any imposed upstream turbulence. This result indicates that the entropy-generated turbulence may be more significant than the hydrodynamically generated turbulence in the turbino stages of aircraft engines.

S.D.

A79-49326 \* # Fundamental mechanisms that influence the estimate of heat transfer to gas turbine blades. R. W. Graham (NASA, Lewis Research Center, Fundamental Heat Transfer Section, Cleveland, Ohio). American Society of Mechanical Engineers and American Institute of Chemical Engineers, National Heat Transfer Conference, San Diego, Culif., Aug. 5-8, 1979, Paper, 11, p. 32 refs.

Heat transfer problems in aircraft gas turbines required for improved prediction of turbine blade or vane gas side heat transfer are examined. Estimates of the heat transfer from the gas to vanes or rotating blades are uncertain due to the complexity of the heat transfer, processes, since the gas flow is three dimensional with complex secondary viscous flow patterns that interact with the andwells and blade susfaces. In addition, upstream disturbances, stagnation flow, curvature effects, and flow acceleration complicate the thermal transport inechanisms in the boundary layers. The thermal state and flow characteristics of the hot gases that enter the turbine blade row, analytical methods for calculating the gas-side heat transfer to turbine blades, and flow phenomena such as stagnation, curvature effects, acceleration, secondary flows, and transition that influences local heat transfer rates are discussed. A T.

A79-49535 \* # Condensation on a noncollapsing vapor bubble in a subcooled liquid. K. J. Baumeister and R. J. Simoneau (NASA, Levis Research Center, Cleveland, Ohio). National Heat Transfer Conference 18th, San Diego, Calif., Aug. 5-8, 1979, Paper, 15 p. 13 rets.

An experimental procedure is presented by which an estimate can be made of the condensation coefficient on a negocilapsing stationary vapor bubble in subcooled liquid ritrogen. The present experimental study utilizes film boiling from a thin wire to generate vapor bubbles which remain fixed to the wire at their base. A balance was established between the evaporation in the thin annular region along the wire and the condensation in the vapor bubbles. (Author)

N79-12366\* United Technologies Research Center East Hartford Conn

DEVELOPMENT OF A THREE DIMENSIONAL TURBULENT DUCT FLOW ANALYSIS Final Report

P. R. Eiseman, R. Levy, H. McDonald, and W. R. Briley. Nov. 1978–117. p. refs. (Contract NAS3-19856)

(NASA-CR 3029) Avail NTIS HC A06/MF A01 CSCL 20D. A method for computing three-dimensional turbulent subsonic flow in curved ducts is described. An approximate set of governing equations is given for viscous flows which have a primary flow direction. The derivation is coordinate invariant, and the resulting equations are expressed in terms of tensors. General tube-like coordinates were developed for a general class of geometries applicable to many internal flow problems. The coordinates are then particularized to pipes having superelliptic cross sections whose shape can vary continuously between a circle and a near rectangle. The analysis is applied to a series of relevant aerodynamic problems including transition from nearly square to round pipes and flow through a pipe with his S shaped bend.

Author

N79 22428\*# Stanford Univ. Calif

FULL COVERAGE FILM COOLING. 3 DIMENSIONAL MEASUREMENTS OF TURBULENCE STRUCTURE AND PREDICTION OF RECOVERY REGION HYDRODYNAMICS Finel Report.

S Yavuzkurt R J Moffat and W M Kays Mar 1979 188 p

(Contract NAS3-14336) (NASA-CR-3104; SU-HMT-27) Avail: NTIS HC A09/MF A01 CSCL 20D

Hydrodynamic measurements were made with a triaxial hot-wire in the full-coverage region and the recovery region following an array of injection holes inclined downstream, at 30 degrees to the surface. The data were taken under isothermal conditions at ambient temperature and pressure for two blowing ratios: M = 0.9 and M = 0.4. Profiles of the three main velocity components and the six Reynolds stresses were obtained at several spanwise positions at each of the five locations down the test plate. A one-equation model of turbulence (using turbulent kinetic energy with an algebraic mixing length) was used in a two-dimensional computer program to predict the mean velocity and turbulent kinetic energy profiles in the recovery region. A new real-time hotwire scheme was developed to make measurements in the three-dimensional turbulent boundary layer over the full-coverage surface.

N79-22429° Stanford Univ., Calif.

HEAT TRANSFER TO A FULL-COVERAGE, FILM-COOLED SURFACE WITH COMPOUND-ANGLE (30 DEG AND 45 DEG) HOLE INJECTION Final Report

H. K. Kim, R. J. Moffat, and W. M. Kays Feb. 1979 159 p. refs.

(Contract NAS3-14336)

(NASA-CR-3103; SU-HMT-28) Avail: NTIS HC A08/MF A01 CSCL 20D

An experimental study of heat transfer was conducted on a turbulent boundary layer with full-coverage film cooling through an array of holes inclined at 30 deg to the surface and 45 deg to the flow direction (compound-angle injection). Heat transfer coefficients were measured over a range of injectant flows (M = 0 to M = 1.5) and Reynolds numbers at velocities between 9.8 and 16.8 m/s. Data are presented for injectant temperature equal to the wall temperature and injectant temperature equal to the stream temperature. Compound-angle injection gives better thermal protection than in-line, slant-hole injection, but the beneficial effect is minimal in the first six rows of holes. For a value of M = 0.37 the heat transfer coefficient with compoundangle injection was the same as for the slant-angle injection after six rows, but was only one-half the slant-hole value after 11 rows. The data for compound-angle injection show the same general features as fc. slant-angle and normal injection. Recovery is rapid after the last row of holes, with the heat

N73-22434°# TRW Defense and Space Systems Group, Redondo Beach, Calif.

D. Antoniuk and E. E. Luedke Dec. 1978 45 p

(Contract NAS3-21130)

(NASA-CR-159550; TRW-30979-6003-RU-00) Avail: NTIS HC A03/MF A01 CSGL 20D

The development effort for, and the fabrication and testing of, six CTS-type variable conductance heat pipes is described. The heat pipes are constructed of stainless steel, urb niethanol as a working fluid, and a nitrogen/helium mixture as the control gas. The wicking structure consists of interior wall grooves, a metal-felt diametral slab wick, and two wire-mesh arteries. The heat pipes are used to cool two Functional Model/Power Processing Units in a Solar Electric Propulsion prototype BIMOD thruster subsystem assembly. The Power Processing Units convert the electric power from a spacecraft solar array system to the voltages required to operate the electric thrusters which are part of the BIMOD assembly.

G.Y.

N79-25349\* # TRW Defense and Space Systems Group, Redondo Beach, Calif

HEAT PIPE LIFE AND PROCESSING STUDY Final Report
David Antoniuk and Edward Luedke Apr. 1979 94 p
(Contract NAS3-21200)

(NASA-CR-159581; TRW-32937-6001-TU-00) Avail: NTIS HC A05/MF A01 CSCL 20D The merit of adding water to the reflux charge in chemically and solvent cleaned aluminum/slab wick/ammonia heat pipes was evaluated. The effect of gas in the performance of three heat pipe thermal control systems was found significant in simple heat pipes, less significant in a modified simple heat pipe model with a short wickless pipe section. Use of gas data for the worst and best heat pipes of the matrix in a variable conductance heat pipe model showed a 3 C increase in the source temperature at full on condition after 20 and 246 years, respectively.

N79-28456\*# Detroit Diesel Allison, Indianapolis, Ind.
LASER ANEMOMETER MEASUREMENTS AT THE EXIT OF
A T63-C20 COMBUSTOR Final Report, Sep. 1978 - Apr.
1979

D. B. Zimmerman Apr. 1979 44 p refs Sponsored in part by Army Research and Develop Command. Cleveland (Contract NAS3-21267; DA Proj. 1L1-62209-AH-76) (NASA-CR-159623; DDA-RN-79-4) Avail: NTIS HC A03/MF A01 CSCL 20D

An experimental study of the flow downstream of a T63-C20 gas turbine engine combustor was performed. Laser anemometer measurements of the mean and fluctuating velocities were made in a combustion rig across an annulus simulating the inlet to turbine. A window design suitable for similar measurements in a gas turbine engine was made based on the results of this experiment. Insufficient numbers of naturally-occurring scattering particles were present in the flow. Hollow phenolic particles added to the flow provided adequate signal strength for measurement. For each of the simulated engine operating conditions of flight idle, 30% power and 90% power, both with and without the addition of fuel, the mean velocities and turbulent intensities were uniform across the annulus. The turbulent intensity was substantially unaffected by the addition of fuel but was apparently only dependent on the inlet flow condition at a given power point. Little or no swirl was present in the flow at the annulus.

N79-30514\*# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechanics.

A CALCULATION PROCEDURE FOR VISCOUS FLOW IN TURBOMACHINES, VOLUME 1

I. Khalil and W. Tabakoff Jul. 1979 97 p refs (Contract NAS3-21639; DA Proj. 1L1-61102-AH-45) (NASA-CR-159635) Avail: NTIS HC A05/MF A01 CSCL 20D

A method for analyzing the nonadiabatic viscous flow through turbomachine rotors is presented. The field analysic is based upon the numerical integration of the full incompressible stream function vorticity form of the Navier-Stokes equations, together with the energy equation, over the rotor blade-to-blade stream channels. The numerical code used to solve the governing equations employs a nonorthogonal boundary fitted coordinate system that suits the most complicated blade geometries. A numerical scheme is used to carry out the necessary integration of the elliptic governing equations. The flow characteristics within the rotor of a radial inflow turbine are investigated over a wide range of operating conditions. The calculated results are compared to existing experimental data. The flow in a radial compressor is analyzed in order to study the behavior of viscous flow in diffusing cascades. The results are compared qualitatively to known experimental trends. The solution obtained provides insight into the flow phenomena in this type of turbomachine. It is concluded that the method of analysis is guite general and gives a good representation of the actual flow behavior within turbomachine passages.

# N79-33432°# General Dynamics/Convair. San Diego, Calif. STUDY OF LIQUID AND VAPOR FLOW INTO A CENTAUR CAPILLARY DEVICE

M H Blatt and J A Risberg Sep 1979 161 p refs (Contract NAS3-20092)

(NASA-CR-159657: GDC-NAS-79-001) Avail: NTIS HC A08/MF A01 CSCL 20D

The following areas of liquid and vapor flow were analyzed and experimentally evaluated: 1) the refilling of capillary devices with settled liquid, and 2) vapor flow across wetted screens. These investigations resulted in 1) the development of a versatile computer program that was successfully correlated with test data and used to predict Centaur D-1S LO2 and LH2 start basket refilling; 2) the development of a semi-empirical model that was only partially correlated with data due to difficulties in obtaining repeatable test results. Also, a comparison was made to determine the best propel int management system for the Centaur D-1S vehicle. The comparison identified the basline Centaur D-1S system (using pressurization, boost pumps and propellant settling) as the best candidate based on payload weight penalty. However, other comparison criteria and advanced mission condition were identified where pressure fed systems, thermally subcooled boost pumps and capillary devices would be selected as attractive

A79-32912 • Filtering of non-linear instabilities. P. K. Khosla and S. G. Rubin (New York, Polytechnic Institute, Farmingdale, N.Y.). *Journal of Engineering Mathematics*, vol. 13, Apr. 1979, p. 127-141, 10 refs. Grant No. NsG-1244.

For Courant numbers larger than one and cell Reynolds numbers larger than two, oscillations and in some cases instabil ties are typically found with implicit numerical solutions of the fluid dynamics equations. This behavior has sometimes been associated with the loss of diagonal domir ance of the coefficient matrix. It is shown here that these problem, can in fact be related to the choice of the spatial differences, with the resulting instability related to aliasing or nonlinear interaction. Appropriate 'filtering' can reduce the intensity of these oscillations and in some cases possibly eliminate the instability. These filtering procedures are equivalent to a weighted average of conservation and non-conservation differencing. The entire spectrum of filtered equations retains a three-point character as well as second-order spatial accuracy. Burgers equation has been considered as a model. Several filters are examined in detail, and smooth solutions have been obtained for extremely large cell Reynolds numbers.

A79-42890 • Heat transfer from a row of jets impinging on concave semi-cylindrical surface. P. Hrycak (New Jersey Institute of Technology, Newark, N.J.S. S. International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers, Volume 2, (A79-42886 18-34) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 67-72, 27 refs. Grant No. NGR-31-009-004; Contract No. NAS3-11175.

Heat transfer from impinging jets has been analyzed. Based on similarities of the boundary conditions of the related flow fields, analogies between heat transfer from impinging jets at the stagnation point and in the wall jet region have been shown for several flow geometries. Calculation of heat transfer in the stagnation region and in the wall jet region, based on available theory and the parameters, obtained from direct measurements, have been carried out, for the single, round, impinging jets. It has been shown that heat transfer from a row of round jets impinging on flat and concave surfaces can be comprehensively described through analysis of impinging jets of simpler geometries. Finally, experimental results for the local and average heat transfer effects are presented and discussed. Comparisons are made with theory and results of other investigators, with fairly satisfactory agreement. (Author)

# 35 INSTRUMENTATION AND PHOTOGRAPHY

Includes remote sensors, measuring instruments and gages, detectors, cameras and photographic supplies, and holography

For aerial photography see 43 Earth Resources. For related information see also 06 Aircraft Instrumentation, and 19 Spacecraft Instrumentation.

N79-12414\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

## AN ELECTRO OPTIC, HIGH VOLTAGE, TRANSIENT PROBE

Stephan J Posta and Charles ! Michels Oct 1978 13 p

(NASA-TM 79019, E-9588) Avail NTIS HC A02/MF A01 CSCL 14B

A newly developed electro-optic voltage transducer is described. It is capable of measuring 30 ns rise time, floating or single-ended, 0 to 20 kV transients in a high noise environment such as a fast discharge laser or energetic switch system. The voltage transient is detected by a specially developed resistor in series with a light emitting diode. The light output (proportional to voltage) is transmitted remotely via a fiber-optic cable to a detector, and recorder. Typical signals and comparison with commercial probe system signals are described. A ithor

N79-14346\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## INDICATED MEAN-EFFECTIVE PRESSURE INSTRUMENT

William J. Rice. inventor (to NASA) Issued 5 Sep. 1978 5 p. Filed 29 Sep. 1977 Supersedes N77-32461 (15 - 23, p. 3080)

(NASA-Case-LEW-12661-1, US-Patent-4,111,041;

U.S.-Patent-Appl-SN-837796. U.S.-Patent-Class-73-115) Avail U.S. Patent and Trademark Office CSCL 14B

An apparatus for measuring indicated mean effective pressure (IMEP) of an internal combustion piston or rotary engine or of an external combustion engine such as a stirling engine is disclosed. An optical shaft encoder measures crankshaft angle of the engine. Changes in volume with respect to changes in crank angle of one or more cylinders (dV/d theta) is determined either empirically or algebraically from engine geometry and stored in a memory. As the crank angle changes, dV/d theta) is read from the memory and multiplied by chamber or cylinder pressure. The product (P dv/d theta) is then added to the total previously accumulated in the cycle. Each time theta changes by an amount equal to delta theta, the process is repeated. At the end of each engine cycle, the total is equal to the IMEP value for that cycle.

Official Gazette of the U.S. Patent and Trademark Office.

N79-14346\* National Aeronautics and Space Administration Lewis Research Centur, Cleveland, Ohio

# THERMOCOUPLES OF MOLYBDENUM AND IRIDIUM ALLOYS FOR MORE STABLE VACUUM-HIGH TEMPERATURE PERFORMANCE Patent

James F. Morris, inventor (to NASA). Issued 5 Sep. 1978. 5 p. Filed 21 Nov. 1977. Continuation-in-part of abandoned US Patent Appl. SN-667929, filed. 18 Mar. 1973.

(NASA-Case-LEW-12174-2, US Patent-4,111.718.

US-Patent-Appl-SN-853679, US-Patent-Class-136-236

US-Patent-Class-136-202, US-Patent-Appl-SN-667929) Avail US Patent and Trademark Office CSCL 14B

Thermocouples providing stability and performance reliability in systems involving high temperatures and vacuums by employing a bimetallic thermocouple sensor are described. Each metal of the sensor is selected from a group of metals comprising molybdenum and iridium and alloys containing only those two metals. The molybdenum, iridium thermocouple sensor alloys provide bare metal thermocouple sensors having advantageous vapor pressure compatibility and performance characteristics.

The compatibility and physical characteristics of the thermocouple sensor alloys result in improved emf, temperature properties and thermocouple hot junction performance.

Official Gazette of the U.S. Patent and Trademark Office

N79-17192\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FINE PARTICULATE CAPTURE DEVICE Patent

Victor S. Peterson and Robert D. Siewert, inventors (to NASA) Issued 16 Jan. 1979 4 p. Filed 8 Nov. 1973 Supersedes N74-13199 (12 - 4, p. 0420)

(NASA-Case LEW-11583-1; US-Patent-4,134,744;

US-Patent-Appl-SN-414042, US-Patent-Class-55-118;

US-Patent-Class-55-122, US-Patent-Class-55-127

US-Patent-Class-55-155; US-Patent-Class-55-241;

US-Patent-Class-55-242, US-Patent-Class-55-360;

US-Patent-Class-55-407) Avail: US Patent and Trademark Office CSCL 14B

To capture fine particulate matter in a gas such as air, a dielectric fluid is directed to the center of whichever face of a rotating disc is exposed to the air flow. The disc is comprised of two or more segments which bear opposite electrostatic potentials. As the dielectric fluid is centrifuged towards the periphery of the rotating disc, the fluid becomes charged to the same potential as the segment over which it is passing. Particulate matter is attracted to the charged segment and is captured by the fluid. The fluid then carries the captured particulate matter to a collection device such as a toroidal container disposed around the periphery of the disc. A grounded electrically-conductive ring may be disposed at the outer periphery of the disc to neutralize the captured particles and the fluid before they enter the container.

Official Gazette of the U.S. Patent and Trademark Office

N79-17195\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HOLOGRAPHY THROUGH OPTICALLY ACTIVE WINDOWS Arthur J Decker Feb. 1979 18 p refs.

(NASA-TP-1414 E-9808) Avail NTIS HC A02/MF A01 CSCL 14E

By using two orthogonally polarized reference beams holograms can be received through stressed windows and the reconstructed virtual image will show no stress pattern. As shown analytically, the stress-pattern-free hologram is recordable for any polarization state of the object illumination. Hence, the more efficient nondepolarizing diffuser can be used in performing holography through stressed windows if two reference beams are used. Results are presented for a pair of machined polysulfone windows intended for use in a holographic flow-visualization setup in a single-stage-compressor test rig.

Author.

N79-22448\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

## MEASURING UNSTEADY PRESSURE ON ROTATING COMPRESSOR BLADES

David R. Englund. Howard P. Grant (Pratt and Whitney Aircraft, East Hartford, Conn.), and George A. Lanati (Pratt and Whitney Aircraft, East Hartford, Conn.). 1979. 28 p. refs. Presented at the 25th Intern. Instrumentation Symp. Anaheim, Calif., 7-10. May 1979, sponsored by the Instr. Soc. of Am.

(NASA-TM-79159, E-015) Avail NTIS HC A03/MF A01 CSCL 148

Miniature semiconductor strain gage pressure transducers mounted in several arrangements were studied. Both surface mountings and recessed flush mountings were tested. Test parameters included mounting arrangement, blade material, temperature, local strain in the occeleration normal to the transducer diaphragm, centripetal acceleration, and pressure. Test results show no failures of transducers or mountings and indicate an uncertainty of unsteady pressure measurement of approximately or 6 percent +0.1 kPa for a typical application. Two configurations were used on a rotating fan flutter program. Examples of transducer data and correction factors are presented.

N79-27480°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EVALUATION OF MINIATURE SINGLE-WIRE SHEATHED THERMOCOUPLES FOR TURBINE BLADE TEMPERATURE MEASUREMENT

Raymond Hollanda Jun. 1979 20 p refs (NASA-TM-79173: E-068) Avail NTIS HC A02/MF A01 CSCL 09A

Chromel Alumel thermocouples were used, with sheath diameters of 0.15 and 0.25 mm. Tests were conducted at temperatures ranging from 750 to 1250 K. Both steady state and : ermal cycling tests were performed for times up to 200 hours. Initial testing was performed in a low velocity gas stream for long time periods using a Meker-type burner. Additional testing was done in a high velocity gas stream for short time periods using a hot gas tunnel and also in a J75 jet engine. A total of eleven 0.15 mm diameter thermocouples and six 0.25 mm diameter thermocouples were tested. Drift rates up to 2.5% in 10 hours were observed. Photomic: paraphs show that this design is near the limit of miniaturization based in present manufacturing capabilities. Results indicate that the effects of miniaturization on reliability and accuracy must be considered when choosing thermocoupies for a particular application.

A79-10800 \* # Pressure instrumentation for gas turbine engines - A review of measurement technology, E. C. Armentrout (NASA, Lewis Research Center, Cleretand, Ohio) and J. C. Kicks (Kulite Semiconductor Products, Inc., Biggefield, N.J.). American Society of Mechanical Engineers, Gas Turbure Conference and Products Show, London, England, Apr. 9.13, 1978, Paper 78-GT-148, 11 p. 50 refs. Members, \$1,50, nonmembers, \$3.00.

Many types and designs of pressure measuring instrumer, ation are used during the development and testing of gas turbine engines This paper provides an overview of more commonly available pressure transducers and their characteristics. Probe designs for use in both steady-state and dynamic pressure measurement systems are reviewed. Techniques used to qualify instrument probes and the methods used to calibrate pressure transducers during engine testing are described. (Author)

Auger spectroscopy analysis in adhesion, friction and wear studies. D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio). International Advances in Nondestructive Testing, vol. 5, 1977, p. 303-320, 18 refs.

The paper reviews the current use of Auger electron spectroscopy in adhesion, friction, wear and lubrication studies. Conventional Auger spectroscopy is adopted to complement LEED studies of the adhesion of metal single crystals. In addition, Auger cylindrical mirror analysis is applied to the study of changes in surface chemistry during dynamic friction and wear experiments on polycrystalline metals and alloys. Important conclusions are that (1) segregation of alloying elements to the surface of metals can after adhesion behavior. (2) hydrocarbons are adsorbed readily to clean iron surfaces at 23 C. (3) transfer from one surface to another for dissimilar materials in contact can be followed in sliding or rubbing friction studies, and (4) the friction process can enhance surface activity for metals with hydrocarbons. SD

A79-15067 \* Global sensing of gaseous and aerosol trace species using automated instrumentation on 747 airliners. P. J. Perkins and L. C. Papathakos (NASA, Lewis Research Cenier, Cleveland, Ohio). In: Joint Conference on Sensing of Environmental Pollutants, 4th, New Orleans, La., November 6-11, 1977, Proceedings. (A79 15023 (4-45) Washington, D.C., American Chemical Society, 1978, p. 307-312, 8 refs.

The Glot... Atmospheric Sampling Program (GASP) is collecting and analyzing data on gaseous and aerosol trace contaminants in the upper troposphere and lower stratosphere. Measurements are obtained from automated systems installed on four 747 airliners flying global air routes. Improved instruments and analysis techniques are providing an expanding data base for trace species including ozone,

carbon monoxide, water vapor, condensation nuclei, and mass concentration of sulfates and nitrates. Simultaneous measurements of several trace species obtained frequently can be used to identify the source of the air mass as being typically tropospheric or stratosni eric.

Improved apparatus for trapped radical and A79-20742 \* other studies down to 1.5 K. J. A. Woollam and K. Sugawara (NASA, Lewis Research Center, Cleveland, Ohio). Review of Scientific Instruments, vol. 49, Dec. 1978, p. 1745.

A Dewar system and associated equipment for electron paramagnetic resonance (EPR) studies of trapped free radicals and other optical or irradiation experiments are described. The apparatus is capable of reaching a temperature of 1.5 K and transporting on the order of 20 W per K temperature gradient; its principal advantages are for use at pumped cryogen temperatures and for experiments with large heat inputs. Two versions of the apparatus are discussed, one of which is designed for EPR in a rectangular cavity operating in a TE(102) mode and another in which EPP is performed in a F.G.M. cylindrical microwave cavity.

N79-12418\* Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.

INSTRUMENTATION FOR MEASURING THE DYNAMIC PRESSURE ON ROTATING COMPRESSOR BLADES Final Report

H P Grant and George A Lanati Sep 1978 182 p (Contract NAS3-20296)

PWA-5558-12) WASA LH-159466. Avail

HC A09/MF A01 CSCL 14B

To establish the capability for measurement of oscillatory pressure on rotating blades, miniature fast response semiconductor strain gage pressure transducers (2mm x 0 33mm) were mounted in several configurations on thin titanium and steel compressor Llades and subjected to pressure cycles from i to 310 kPa during static tests and spin tests. Static test conditions included 20 C :n 150 C, 0 to 3000 tensile microstrain. 1000 to + 1000 bending inicrostrain and + or - 650G vibration. The spin test conditions included 20 C to 82 C at 0 to 90,000G. Durability was excellent. Pressure transducer sensitivity changed by only a few percent over this range of environmental conditions. Noise signal due to oscillatory acceleration normal to the diaphragm was acceptable (0.33Pa/G). Noise signal due to oscillatory strain was acceptable (0.5 Pa/microstrain) when the transducer was mounted on a 0.05mm rubber pad, with a total buildup of 0.38mm on the measure surface. Back mounting or partial recessing to eliminate buildup, increased the strain effect 1.2 Pa/microstrain Flush mounting within the blade to eliminate buildup reduced the strain effect, but required development of a special transduce shape. This transducer was not available in time for spin lests. Unpredictable zero drift + or - 14 kPa ruled out the use of these mounting arrangements for accurate steady-state (D.C.) measurements on rotating blades. The two pest configurations fully developed and spin tested were then successfully applied in the NAS3-20606 rotating fan flutter program for quantitative measurement of oscillatory pressure amplitudes Author

N79-19314\*# Pratt and Whitney Aircraft, East Hartford. Conn. Commercial Products Div

STRAIN GAGE SYSTEM FVALUATION PROGRAM Final Report

G. W. Dolleris, H. J. Mazur, and E. Kokoszka, Jr. Dec. 1978 126 p

(Contract NAS3-20298)

PWA-5615-31 NTIS NASA CR 159486.

HC A07/MF A01 CSCL 14B

A program was conducted to determine the reliability of various strain gage systems when applied to rotating compressor blades in an aircraft gas turbine engine. A survey of current technology strain gage systems was conducted to provide a basis for selecting candidate systems for evaluation. Testing and evaluation was conducted in an F 100 engine. Sixty strain gage systems of seven different designs were installed on the first

and third stages of an F 100 engine fan. Nineteen strain gage failures occurred during 62 hours of engine operation, for a survival rate of 68 percent. Of the failures, 16 occurred at blade-to-disk leadwire jumps (84 percent), two at a leadwire splice (11 percent), and one at a gage splice (5 percent). Effects of erosion, temperature, G-loading, and stress levels are discussed. Results of a post-test analysis of the individual components of each strain gage system are presented.

N79-21329\* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

## SIMULATED ELECTRONIC HETERODYNE RECORDING AND PROCESSING OF PULSED-LASER HOLOGRAMS

Arthur J. Decker Apr. 1979 40 p. refs (NASA-TP 1444, E-9813) Avail. NTIS HC A03/MF A01 CSCL

The electronic recording of pulsed-laser holograms is proposed. The polarization sensitivity of each resolution element of the detector is controlled independently to add an arbitrary phase to the image waves. This method which can be used to simulate heterodyne recording and io process three-dimensional optical images, is based on a similar method for heterodyne recording and processing of continuous-wave holograms. A.R.H.

N79-26384\*# Mathematical Sciences Northwest, Inc., Bellevue,

#### DESIGN INVESTIGATION OF SOLAR POWERED LASERS FOR SPACE APPLICATIONS Final Report

R. Taussig, C. Bruzzone, D. Quimby, L. Nelson, W. Christiansen, S. Neice, P. Cassady, and A. Pindroh. May 1979. 184 p. refs. (Contract. NAS3-21134).

(NASA-CR 159554, MSNW 79-1087/1090-1) Avail NTIS HC A09/MF A01 CSCL 20E

The feasibility of solar powered lasers for continuous operation in space power transmission was investigated. Laser power transmission in space over distances of 10 to 100 thousand kilometern appears possible. A variety of lasers was considered, including solar powered GDLs and EDLs, and solar-pumped lasers. An indirect solar pumped laser was investigated which uses a solar-heated black body cavity to pump the lasant. Efficiencies in the range of 10 to 20 percent. The projected for these indirect optically pumped lasers.

G.Y.

N79-27478\* Creare, Inc., Hanover, N.H.

# DESIGN, DEVELOPMENT, AND TEST OF A LASER VELOCIMETER FOR A SMALL 8:1 PRESSURE RATIO CENTRIFUGAL COMPRESSOR Final Report

Francis X Dolan and Peter W Runstadler, Jr. Mar. 1979 206 p. refs.

(Contract NAS3 17860)

(NASA CR 134781. Creare TN 289) Avail NTIS HC A10/MF A01 CSCL 146

The instrument was designed as a diagnostic tool for the basic fluid dynamics of the inducer, impeller, and diffuser regions of this type compressor. The LV instrumentation was optimized to measure instantaneous velocities up to approximately 500 m/s. measured in absolute coordinates, within the rotating compressor impelier and in the two dimensional radial plana ci the diffuser Some measurements were made within the diffuser and the impeller inlet flows however attempts to nake detailed measurements of the velocity field were not successful. Difficulties in maintaining high seed particle rates within the probe volume and the improper operation of the blade gating optics may explain the lack of success. Recommendations are made to further pursue. these problems. At 100% speed the stage attained a total static pressure ratio of 7.5.1 at 75% total static efficiency. Flow range from choke to furge was 6.8% of choking mass flow rate Performance was lower than the design intent of 8.1 pressure atio at 77% efficiency and 12% flow range. Detailed measurements of the stage components are presented which show the reasons for the stage performance deficiencies. SES

A79-38738 \* Fiber optic sensors for military, industrial and commercial applications. K. A. James, W. H. Quick, and V. H. Strahan (Rockwell International Corp., Electronics Research Center, Anaheim, Calif.). In: ITC/USA/78, Proceedings of the International Telemetering Conference, Los Angeles, Calif., November 14-16, 1978. (A79-38676 16-32) Pittsburgh, Pa., Instrument Society of America, 1978, p. 777-782. Contract No. NAS3/21005.

Four exampler of specific fiber optic sensor system designs, each of which demonstrates a different optical modulation format, are described. The birefrigent temperature transducer illustrates direct digital signal modulation. The temperature/pressure dependent semi-conductor filter illustrates high-pass optical wavelength signal encoding. The coupled polarized-mode transducer shows how a solid-state sensor can produce narrow-bandpass optical wavelength signal encoding. The luminescent temperature sensor illustrates a way to construct a solid state sensor in order to produce pulse width modulation of an optical signal.

B.J.

### 36 LASERS AND MASERS

Includes parametric amplifiers.

A79-19078 \* Gain measurements of the Ca-Xe charge exchange system. C. J. Michels and D. L. Chubb (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Applied Physics*, vol. 49, Oct. 1978, p. 5084-5092, 16 refs.

Charge-exchange-pumped Ca(+) was studied for possible positive laser gain at 370.6 and 315.9 nm using an Xe MPD arc as the Xe(+) source. The present paper describes the MPD arc, the calcium injection system, the diagnostics for gain, and spontaneous emission measurements and results. No positive gain measurements were observed. A small Xe-Ca charge exchange cross section compared to He-metal laser systems charge exchange cross sections is the most probable reason why the result was negative.

B.J.

N79-21334\* Lockheed Missiles and Space Co., Palo Alto. Calif. Research Lab

LASER POWER CONVERSION SYSTEM ANALYSIS, VOLUME 1 Final Report, 26 Sep. 1977 - 26 Sep. 1978 W. S. Jones, L. L. Morgan, J. B. Forsyth, and J. P. Skratt 15 Mar. 1979 - 109 p. refs

(Contract NAS3-21137) (NASA-CR-159523-Vol-1 LMSC-DF73466-Vol-1) Avail NTIS

HC A06/MF A01 CSCL 208

The orbit-to-orbit laser energy conversion system analysis established a mission model of satellites with various orbital parameters and average electrical power requirements ranging from 1 to 300 kW. The system analysis r aluated various

from 1 to 300 kW. The system analysis r aluated various conversion (echniques, power system deployment parameters, power system electrical supplies and other critical subsystems relative to various combinations of the mission model. The analysis show that the laser power system would not be competitive with current satellite power systems from weight, cost and development risk standpoints. Author

N79-21335°# Lockheed Missiles and Space Co., Palo Alto. Calif. Research Lab.

LASER POWER CONVERSION SYSTEM ANALYSIS, VOLUME 2 Final Report, 26 Sep. 1977 - 26 Sep. 1978

W. S. Jones, L. L. Morgan, J. B. Forsyth, and J. P. Skratt 15 Mar 1979, 112 p. refs (Contract NAS3-21137)

(NASA-CR-159523-Vol-2 LMSC-D673466-Vol-2). Avail NTIS HC A06/MF A01 CSCL 20E

The orbit-to-ground laser power conversion system analysis investigated the feasibility and cost effectiveness of converting solar energy into laser energy in space, and transmitting the laser energy to earth for conversion to electrical energy. The analysis included space laser systems with electrical outputs on the ground ranging from 100 to 10,000 MW. The space laser power system was shown to be feasible and a viable alternate to the nucrowave solar power satellite. The narrow laser beam provides many options and alternatives not attainable with a microwave beam.

N79-21337°# Lockheed Missiles and Space Co., Sunnyvals, Calif. Research Lab.

LASER ROCKET SYSTEM ANALYSIS Final Report, 27 Sep. 1976 - 27 Rep. 1978

W S Jones, J B Forsyth, and J P Skratt 1t Mar 1979

(Contract NAS3-20372)

(NASA-CR-159521. LMSC-D564671A) Avail NTIS HC A09/MF A01 CSCL 20E

The laser rocket systems investigated in this study were for orbital transportation using space-based ground-based and airborne laser transmitters. The propulsion unit of these systems utilizes a continuous wave (CW) laser beam focused into a thrust chamber which initiates a plasma in the hydroger propellant, thus heating the propellant and providing thrust through a

suitably designed nozzle and expansion skirt. The specific impulse is limited only by the ability to adequately cool the thruster and the amount of laser energy entering the engine. The results of the study showed that, with advanced technology, laser rocket systems with either a space- or ground-based laser transmitter could reduce the national budget allocated to space transportation by 10 to 345 billion dollars over a 10-year life cycle when compared to advanced chemical propulsion systems (LO2-LH2) of equal capability. The variation in savings depends upon the projected mission model.

# N79-32538\*# Rockwell International Corp., Anaheim, Calif. HIGH POWER PHASE LOCKED LASER OSCILLATORS Final Report

C. L. Hayes, C. L. Telk, J. Soohoo, and W. C. Davis. May 1979 103 p. refs.

(Contract NAS3-20376)

(NASA-CR-159630. C76-1555/501) Avail NTIS HC A06/MF A01 CSCL 20E

The feasibility of mechanizing an adaptive array of independent laser oscillators for generation of a high power coherent output was experimentally investigated. Tests were structured to evaluate component/system requirements for delivery of energy to a low-earth orbit satellite. Initial experiments addressed the control issues of phase locking unstable resonators at low power levels. A successful phase lock demonstration formed the basis for the design and fabrication of the high power, water-cooled, control mirror subsequently installed in the NASA LeRC high power laser. Tests were performed to characterize the operational limits of the laser system and included quantitative assessment of the frequency stability, noise sources, and optical properties of the beam.

A79-32981 \* Simmer-enhanced flashlamp-pumped dye laser. T. K. Yee, T. K. Gustafson (California, University, Berkeley, Calif.), and B. Fan (IBM Thomas J. Watson Research Center, Yorktown Heights, N.Y.). Applied Optics, vol. 18, Apr. 15, 1979, p. 1131, 1132. Grants No. DAHCO4-75-C-0095; No. NsG-2151.

It has been demonstrated experimentally that by enhancing the simmer current in the flash lamps before the energy discharge, the lamp inductance is reduced and the dye laser efficiency is thus remarkably improved. This technique has advantages over the prepulsing technique for conditioning flash lamps, the electronic circuit for the simmer enhancement is simple, inexpensive and reliable, and accurate timing is not required. Furthermore, the simmer enhancement consumes much less power, thus minimizing the attendant thermal effects and improving overall laser efficiency.

A79-38202 \* a Solar-pumped lasers for space power transmission. R. Taussig, C. Bruzzone, L. Nelson, D. Quimby (Mathematical Sciences Northwest, Inc., Bellevue, Wash.), and W. Christiansen (Washington, University, Seattle, Wash.). American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1015. 18 p. 40 refs. Contract No. NAS3 21134.

Multi-Megawatt CW solar-pumped lasers appear to be technologically feasible for space power frainsmission in the 1990s time frame. A new concept for a solar pumped laser is presented vinch utilities an intermediate black body cavity to provide a uniform optical pumping environment for the lasant, either CO or CO2. Beradiation losses are minimized with resulting high efficiency operation. A 1 MW output laser may weigh as little as 8000 kg including solar collector, black body cavity, laser cavity and ducts, pumps, power systems and waste heat radiator. The efficiency of such a system will be on the order of 10 to 20%. Details of the new concept, laser design, comparison to competing solar-powered lasers and applications to a laser solar power satellite (SPS) concept are presented. (Author)

### 37 MECHANICAL ENGINEERING

includes auxiliary systems (non-power), machine elements and processes, and mechanical equipment.

N79-10418\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### CANTILEVER MOUNTED RESILIENT PAD GAS BEARING Patent

Izhak Etsion, inventor (to NASA) (NAS-NRC, Washington, D.C.) Issued 11 Jul 1978 6 p Filed 28 Apr 1977 Supersedes N77 24496 (15 - 15, p 1998) Sponsored by NASA (NASA Case LEW 12569-1, US Patent 4.099.799

US-Patent-Appl-SN-792069. US Patent-Class-308-5R;

US-Patent-Class-308-9, US-Patent-Class-308-121,

US-Patent-Class-308-160, US-Patent-Class-308-163,

US-Patent-Class 308-172, US-Patent-Class-308-DIG 1) Avail US Patent Office CSCL 11A

A gas lubricated bearing is described, employing at least one pad mounted on a rectangular cantilever beam to produce a lubricating wedge between the face of the pad and a moving surface. The load carrying and stiffness characteristics of the pad are related to the dimensions and modulus of elasticity of the beam. The bearing is applicable to a wide variety of types of hydrodynamic bearings Official Gazette of the U.S. Patent Office

N79-10424\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### COMPRESSIBLE FLOW ACROSS NARROW PASSAGES COMPARISON OF THEORY AND EXPERIMENT FOR FACE SEALS

Gordon P. Allen, Donald W. Wisander, and William F. Hady Nov 1978 19 p refs

(NASA TP 1346, E 9120) Avail NTIS HC A02/MF AC1 CSCL 11A

Computer calculation for determining compressible flow across radial face seals were compared with measured results obtained in a seal simulator rig at pressure ratios to 0.9 (ambient pressure/sealed pressure). In general, the measured and calculated leakages across the seal dam agreed within 3 percent. The resultant loss coefficient, dependent upon the pressure ratio. ranged from 0.47 to 0.58. The calculated pressures were within 2.5 N/cu um of the measured values GG

N79-10425\* National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

#### ANISOTROPIC FRICTION AND WEAR OF SINGLE CRYSTAL

Kazuhisa Miyoshi (Kanazawa Univ. Japan) and Donald H. Buckley Oct 1978 23 p refs

(NASA TP 1339 E 9673) Avail NTIS HC A02/MF A01 CSCL

Sliding friction experiments were conducted with manganese zinc ferrite (100) (110) (111), and (2)1) planes in contact with themselves. Mating the highest atomic density directions. (110) of matched crystaliographic planes resulted in the lowest coefficients of friction. Mating matched (same) high-atomicdensity planes and matched (same)crystallographic directions resulted in low coefficients of friction. Mating dissimilar crystal lographic planes, however did not give significantly different friction results from those with matched planes. Sliding caused cracking and the formation of hexagonal and rectangular platelet wear debris on fairite surfaces primarily from cleavage of the Author (110) planes

N79-10426\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

#### FREE PISTON REGENERATIVE HOT GAS HYDRAULIC ENGINE Patent Application

Donald G Baremand inventor (to NASA) Filed 12 Oct 1978

(NASA-Case-LEW-12274-1, US-Patent-Appl-SN-950876) Avail NTIS HC A02/MF A01 CSCL 131

A free piston, regenerative, hydraulic engine is described. including displacer piston which is driven by a high pressure or low pressure gas Actuation of the displacer piston circulates the working fluid through a heater, a regenerator, and a cooler This invention includes an inertial mass, such as a piston or a hydraulic fluid column to effectively store and supply energy during portions of the cycle Power is transmitted from the working fluid to a hydraulic fluid across a diaphragm or lightweight piston to achieve a hydraulic power output. The displacer piston may be driven pneumatically, hydraulically, or electromagnetically. The displacer piston and the inertial mass may be positioned on the same side of the diaphragm member or may be separated by NASA the diaphragm member

N79-11403\* National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

#### FUEL DELIVERY SYSTEM INCLUDING HEAT EXCHANGER **MEANS Patent**

George A Coffinberry, inventor (to NASA) (G.E., Cincinnati, Ohio) Issued 8 Aug 1978 6 p Filed 29 Nov 1976 Sponsored by NASA

NASA Case LEW 12793 1, US Patent 4.104.873.

US Patent Appl SN 745766. US Patent-Class 60-39 28R.

US Patent Class 60 39 08. US Patent Class 60 39 66) Avail US Patent Office CSCL 131

A fuel delivery system is presented wherein first and second heat exchanger means are each adapted to provide the transfer of heat between the fuel and a second fluid such as lubricating oil associated with the gas turbine engine. Valve means are included which are operative in a first mode to provide for flow of the second fluid through both first and second heat exchange means and further operative in a second mode for bypassing the second fluid around the second heat exchanger means

Official Gazette of the U.S. Patent Office

N79-12445\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### SELF-STABILIZING RADIAL FACE SEAL Patent Application

I. Etsion, inventor (to NASA) (Technion Research and Development Foundation, Haifa, Israel) Filed 17 Nov 1978, 15 p. Sponsored by NASA

(NASA-Case-LEW-12991-1, US Patent-Appl-SN-961832) Avail NTIS HC A02/MF AU1 CSCL 11A

A self-stabilizing radial face seal is reported that consists of a primary seal ring juxtapositioned to a seal seat. The seal seat is provided with a porous ring-like circumferential structure which allows for the fluid pressure in the system to reach equilibrium. A cavity behind the porous ring provides a constant pressure reservoir NASA

N79-13369°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### PERFORMANCE OF A NASVYTIS MULTIROLLER TRACTION DRIVE

Stuart H Loewenthal Neil E Anderson (AVRADCOM Res. and Technol Labs.), and Algirdas L. Nasvytis (Transmission Res., Inc.) Nov 1978 36 p refs

(NASA TP 1378, E-9632, AVRADCOM-TR-78-36) Avail NTIS HC A03/MF A01 CSCL 131

Tests were conducted to determine the operational and performance characteristics of a high-speed, 14.7-to-1 fixed-ratio Nasvytis Multiroller Traction Drive at speeds to 73,000 rpm and power levels to 127 kW (170 hp) The test drive was arranged in a single-stage, planetary configuration with two rows of stepped planet rollers contained between concentric sun and ring rollers it was jubricated with a traction fluid. Two drives were :ested concurrently in a back-to-back arrangement They exhibited good performance and operated smoothly, with a nominal peak efficiency of 95 percent. Variations of the design traction coefficient imposed by the automatic roller-loading device

of 0.039, 0.048, and 0.057 seemed to have relatively little effect on any of the operating variables.

excessive carbon content in the case, excessive case depth, and a higher than normal core hardness.

N79-14386\* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

# FRICTION AND TRANSFER OF COPPER, SILVER, AND GOLD TO IRON IN THE PRESENCE OF VARIOUS AD-

Donald H. Buckley Jan. 1979 19 p refs

(NASA-TP-1392; E-9684) Avail: NTIS HC A02/MF A01 CSCL 20K

Sliding friction experiments were conducted with the noble metals copper, silver, and gold and two binary alloys of these metals contacting iron in the presence of various adsorbates including, oxygen, methyl mercaptan, and methyl chloride A pin on disk specimen configuration was used with a load of 100 grams, sliding velocity of 60 mm/min; at 25 C with the surfaces saturated with the adsorbates. Auger emission spectroscopy was used to monitor surface films. Results of the experiments indicate that friction and transfer characteristics are highly specific with respect to both the noble metal and surface film present. With all three metals and films transfer of the noble metal to iron occurred very rapidly. With all metals and films transfer of the noble metal to iron continuously increased with repeated passes except for silver and copper sliding on iron sulfide.

Author

N79-14387° National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

#### FRICTION AND WEAR CHARACTERISTICS OF IRON-CHROMIUM ALLOYS IN CONTACT WITH THEMSELVES AND BLUCON CARBIDE

Kazuhisa Miyoshi and Donald H Buckley Jan 1979 23 p

(NASA-TP-1387; E-9670) Avail: NTIS HC A02/MF A01 CSCL 20K

Sliding friction experiments were conducted with various iron-chromium alloys in contact with (1) themselves, (2) single crystal silicon carbide disks, and (3) single crystal abrasive grit of silicon carbide. Results indicate the coefficients of friction for the alloys sliding against themselves are between those for pure iron and pure chromium, and are only slightly different with 1, 5, 9, 14, and 19 weight percent chromium in iron. The wear is due, primarily, to shearing, or tearing fracture, of the cohesive bonds in the bulk metal and plowing of the bulk by lumps of wear debris. There are only slight differences in the coefficients of friction for the various alloys when sliding on silicon carbide. The coefficient of friction for the alloys are higher than those for pure iron and pure chromium. Alloy hardening observed in the alloys plays a dominant role in controlling the abrasive friction and wear behavior of the alloys.

Author.

N79-14389\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## EVALUATION OF CBS 600 CARBURIZED STEEL AS A GEAR MATERIAL

Dennis P. Townsend, Richard J. Parker, and Erwin V. Zaretsky Jan. 1979, 27, p. refs. (NASA TR 1390, E. 9651), April NTIS, NC A03/ME A01, CCC.

(NASA-TP-1390, E-9651) Avail NTIS HC A03/MF A01 CSCL

Gear endurance tests were conducted with one lot of consumable-electrode vacuum-melted (CVM) AISI 9310 gears and one lot of air-melt CBS 600 gears. The gears were 8 pitch with a pitch diameter of 8.89 centimeters (3.5 in.). Bench-type rolling element fatigue tests were also conducted with one lot of CVM AISI 9310, three lots of CVM CBS 600, and one of air-melt CBS 600 material. The rolling-element bars were 0.952 centimeter (0.375 in.) in diamete. e. CBS 600 material exhibited pitting fatigue lives in both receivement specimens and gears at least equivalent to that of cVM AISI 9310. Tooth fracture failure occurred with the CBS 600 gears after overruning a fatigue spall, but it did not occur with the CVM AISI 9310 gears. Tooth fracture in the CBS 600 was attributed to

N79-17227\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

#### FRICTION AND WEAR WITH A SINGLE-CRYSTAL ABRA-SIVE GRIT OF SILICON CARBIDE IN CONTACT WITH IRON BASE BINARY ALLOYS IN OIL: EFFECTS OF ALLOYING ELEMENT AND ITS CONTENT

Kazuhisa Miyoshi (Kanazawa Univ., Japan) and Donald H. Buckley Feb. 1979 19 p.

(NASA-TP-1394; E-9765) Avail. NTIS HC A02/MF A01 CSCL 20K

Sliding friction experiments were conducted with various iron-base binary alloys (alloying alaments were Ti, Cr, Mn, Ni, Rh, and W) in contact with a rider of 0.025-millimeter-radius, single-crystal silicon carbide in mineral oil. Results indicate that atomic size and content of alloying element play a dominant role in controlling the abrasive-wear and -friction properties of iron-base binary alloys. The coefficient of friction and groove height (wear volume) general alloy decrease, and the contact pressure increases in solute content. There appears to be very good correlation of the solute to iron atomic radius ratio with the decreasing rate of coefficient of friction, the decreasing rate of groove height (wear volume), and the increasing rate of contact pressure with increasing solute content C. Those rates increase as the solute to iron atomic radius ratio increases from unity.

C

N79-18318\* National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

#### COMPOSITE SEAL FOR TURBOMACHINERY Patent

Robert C Bill and Lawrence P Ludwig, inventors (to NASA) Issued 23 Jan 1979 5 p Filed 27 May 1977 Supersedes N77 24498 (15 15 p 1999)

(NASA Case-LEW-12131-1 US Patent 4.135.851. US-Patent Appl-SN 801290. US-Patent Class 415-174.

US Patent Class 415 200) Avail US Patent and Trademark Office CSCL 11A

A gas path seal suitable for use with a turbine engine or compressor is provided. A shroud wearable or abradable by the abrasion of the rotor blades of the turbine or compressor protects the rotor blades. A compliant backing surrounds the shroud. The backing may be made of corrugated sheets or the like with adjacent layers having off set corrugations, with axes of the folds parallel to the rotor axis. The sheets may be bonded together at points of contact by brazing welding or the like. In another embodiment a compliant material is covered with a thin ductile layer. A mounting fixture surrounds the backing.

Official Gazette of the U.S. Patent and Trademark Office

N79-18323\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

## OPERATING CHARACTERISTICS OF A LARGE-BORE ROLLER BEARING TO SPEEDS OF 3 TIMES 10 TO THE 6TH POWER DN

Fredrick T Schuller Feb 1979 32 p refs

(NASA-TP 1413, E 9657) Avail NTIS HC A03, VF A01 CSCL

A 118 millimeter bore roller bearing was studied parametrically at speeds from 10,000 to 25,500 rpm. The bearing had a round outer ring. Inot preloaded) and provisions were made for lubrication and cooling through the inner ring. In some tests the outer ring was also cooled. The bearing ran successfully at 300,00 DN with very small evidence of cage slip. Load, which was varied from 2200 to 8900 newtons (500 to 2000 lb), had no effect on bearing temperature or cage slip over the speed range tested. Bearing temperature varied inversely with cage slip for all test conditions. Cooling the outer ring decreased its temperature but increased the inner ring temperature. Heat rejected to the lubricant spower loss within the bearing increased with both shaft speed and total oil flow rate to the inner ring.

N79-22475° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SHAFT SEAL ASSEMBLY FOR HIGH SPEED AND HIGH PRESSURE APPLICATIONS Patent

William F. Hadt and Lawrence P. Ludwig, inventors (to NASA) Issued 20 Mar. 1979 7 p Filed 8 Jul. 1977 Supersedes N77-27404 (15 - 18, p 2390)

(NASA-Case-LEW-11873-1; US-Patent-4,145,058;

US-Patent-Appl-SN-814006; US-Patent-Class-277-62;

US-Patent-Class-277-96.1) Avail: US Patent and Trademark

Office CSCL 11A

A seal assembly is provided for reducing the escape of fluids from between a housing and a shaft rotably mounted in the housing. The seal assembly comprises a pair of seal rings resiliently connected to each other and disposed in side-by-side relationship In each seal ring, both the internal bore surface and the radial face which faces away from the other seal ring are provided with a plurality of equi-spaced recesses. The seal faces referred to are located adjacent a seating surface of the housing Under normal operating conditions, the seal assembly is stationary with respect to the housing, and the recesses generate life, keep the assembly spaced from the rotating shaft and allow slip therebetween. The seal assembly can seize on the shaft, and slip will then occur between the radial faces and the housing.

Official Gazette of the U.S. Patent and Trademark Office

N79-22518\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

OPERATING CHARACTERISTICS OF LEVER MOUNTED RESILIENT PAD GAS LUBRICATED THRUST BEARING

Zolton N Nemeth Washington Apr 1979 30 p refs (NASA TP-1438 E-9815) Avail NTIS HC A03/MF A01 CSCL

A resilient-pad gas thrust bearing consisting of pads mounted on cantilever beams was tested to determine its operating characteristic. The bearing was run at a thrust load of 74 newtons to a speed of 17000 rpm. The pad film thickness and bearing friction torque were measured and compared with theory. The measured film thickness was less than that predicted by theory The bearing friction torque was greater than that predicted by Author

N79-22519\*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

COMPARISON OF ANALYSIS AND EXPERIMENT FOR SELF-ACTING SEALS FOR LIQUID-OXYGEN TUR ROPUMPS

Gordon P Allen Apr 1979 15 p refs (NASA TP 1443 E 9806) Avail NTIS HC A02/MF A01 CSCL

Two LOX turbopump applications were analyzed over ranges of pressure differential and speed Predictions were compared with test results. A small seal was analyzed up to 101 in/sec and 310 N/sq cm differential and a larger seal up to 147 m/sec and 448 N/sq cm Tests confirmed analytical predictions of operation without rubbing contact. The seals evidently operated with mostly liquid in the pads and mostly gas across the dain although the best prediction of trends was based on assuming gas throughout the entire seal

N79-23430\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

TWO DIMENSIONAL RANDOM SURFACE MODEL FOR ASPERITY CONTACT IN ELASTOHYDRODYNAMIC LU BRICATION

John J Coy (Army Aviation Res and Develop Command Cleveland) and Steven M. Sidik. 1979. 31 p. refs. Presented. at the Intern. Conf. on Metrology and Properties of Engl. Surfaces. Leicester, England, 18 20 Apr., 1979.

INASA TM 79006 AVRADCOM TR 78 48 E 9265 11 Avail NTIS HC A03/MF A01 CSCL 11H

Relations for the asperity contact time function during elastohydrodynamic lubrication of a ball bearing are presented

The analysis is based on a two-dimensional random surface model. and actual profile traces of the bearing surfaces are used as statistical sample records. The results of the analysis show that transition from 90 percent contact to 1 percent contact occurs within a dimensionless film thickness range of approximately four to five This thickness ratio is several times large than reported in the liverature where one-dimensional random surface models were used It is shown that low pass filtering of the statistical records will bring agreement between the present results and those in the literature Author

N79-24350°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

DIAGNOSTICS OF WEAR IN AERONAUTICAL SYSTEMS L D Wedeven 1979 5 p refs Presented at the 15th State-of-the-Art Symp. on Corrosion and Wear, Washington. D C. 4.6 Jun 1979, sponsored by the Am Chem Soc (NASA-TM-79185, E-052) Avail NTIS HC A02/MF A01 CSCL 20K

Maintenance costs associated with the transmissions and drive train greatly increase the maintenance burden and failure risk Detection measurements fall under two general categories of vibration and particle detectors. The latter are more amenable to reaking wear. Wear debris analysis can supply a great deal of information such as particle concentration, rate of change in concentration, composition, particle size and shape, principal metals, etc. It is not economically feasible to monitor all variables At least one role of the lubrication and wear specialist is to provide guidance in selecting the most appropriate variables to

N79-28554\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ELASTOHYDRODYNAMIC FILM THICKNESS MEASURE MENTS OF ARTIFICIALLY PRODUCED NONSMOCTH SURFACES

C Cusano (Illinois Univ. Urbana) and L D Wedeven. 1979 47 p refs Proposed for presentation at Joint Lubrication Conf. Dayton, Ohio. 16-18 Oct 1979, sponsored by Am Soc of Lubrication Engr and the ASME

(NASA-TM-79214: E-9977) Avail NTIS HC A03/MF A01 CSCL 11H

Optical interferometry is used to measure the elastohydrodynamic (EHD) film thickness associated with artificially produced nonsmooth surfaces. The nonsmooth surfaces are produced by modifying the surfaces of highly-polished balls with aregularities in the form of multiple grooves and dents. By closely spacing these irregular, ies it is possible not only to produce depressions on the surface of the balls but also to generate pseudo asperities The average roughness wavelength of this artificially-produced. nonsmooth, surface approximates the average fundamental roughness wavelength found on surfaces of some inechanical elements operating under concentrated contact. By comparing the measured film thickness profiles to the stylus traces of the irregularities, it was possible to observe the local deformations associated with micro-EHD pressure generation. In both pure rolling and pure sliding conditions the artificially-produced asperities are deformed and complete separation exists between them and the mating surface. Such findings femonstrate the importance of local surface topography and res ing micro-EHD effects on the film thickness between rough surfaces in concentrated contact. Sliding data are presented which demonstr ate a severe constriction caused by the irregularities at the Author exit of the Hertzian region

N79-31604\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

EVALUATION OF HIGH CONTACT RATIO SPUR GEARS WITH PROFILE MODIFICATION

Dennis P Towsend Berl B Baber (Southwest Research Inst. San Antonio Tex I and Andrew Nagy (Southwest Research Inst. San Antonio Tex | Sep 1979 24 p refs (NASA TP 1458 E 9949) Avail NTIS HC A02/MF A01 CSCL

Scoring tests, surface fatigue tests, and single tooth bending

fatigue tests were conducted with four sets of spur gears of standard design and three sets of spur gears of new-tooth-form design. The new-tooth-form and standard gears scored at approximately the same gear bulk temperature of 409 K (277 F). The scoring load for the new-tooth-form gears was 22 percent less than that for the standard gears. The pitting fatigue lives of the standard and new-tooth-form gears were statistically equal for equal. Hertz stress, while the surface fatigue life of the nw-tooth-form gears was approximately five times that of the standard gears at the same load. The standard gears failed at a 17 percent higher bending stress than the new-tooth-form gears when stress was calculated by the AGMA method. However, the difference is not statistically significant. The standard gears failed at a tooth load 1.9 times that for the new-tooth-form gears.

Author.

N79-31605\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## FERROGRAPHIC ANALYSIS OF WEAR DEBRIS FROM FULL SCALE BEARING FATIGUE TESTS

William R. Jones, Jr. and Stuart H. Loewenthal. Sep. 1979 19 p. refs.

(NASA-TP-1511, E-9827) Avail NTIS HC A02/MF A01 CSCL

The Ferrograph was used to determine the types and quantities of wear particles generated during full scale bearing fatigue tests. Deep-groove ball bearings made from steel were used. A tetraester lubricant was used in a recirculating lubricant system containing a 49 micrometers absolute filter. Test conditions include a maximum. Hertz stress of 2.4 GPa, a shaft speed of 15,000 rpm, and a lubricant supply temperature of 74 C (165.F). Four fatigue failures were detected by accelerometers in this test set. In general, the Ferrograph was more sensitive (up. to. 23. hr) in detecting spall initiation than either accelerometers or the normal sepectrographic oil analysis. Four particle types were observed normal rubbing weather particles, spheres, nonferrous particles, and severe wear (spall) fragments.

N79-32552\*# National Aeronaut is and Space Administration.
Lewis Research Center, Cleveland, Unio

# CG. PARISON OF PREDICTED AND MEASURED ELASTOHYDRODYNAMIC FILM THICKNESS IN A 20-MILLIMETER-BORE BALL BEARING

John J Coy, Rama S R. Gorla (Cleveland State Univ., Ohio), and Dennis P Townsend Oct 1979 29 p refs (NASA-TP-1542, AVRADCOM-TR-79-20, E-9992) Avail NTIS

(NASA-TP-1542, AVRADCOM-TR-79-20, E-9992) Avail NTIS HC A03/MF A01 CSCL 131

Elastohydrodynamic film thicknesses were measured for a 20-mm bore ball bearing using the capacitance technique. The bearing was thrust loaded to 90, 44b, and 778 N (20, 100, and 175 lb). The corresponding maximum contact stress on the inner race was 1.28, 2.09 and 2.45 GPa (185.000, 303.000, and 356.000 psi). Test speeds ranged from 400 to 15,000 rpm Measurements were taken with four different lubricants (1) synthetic paraffinic. (2) synthetic paraffinic with additives. (3) synthetic type II aircraft oil, and (4) synthetic cycloaliphatic hydrocarbor, traction fluid. The test bearing was mist lubricated Test temperatures were 27, 65, and 121.0 (80, 150, and 250.F). The measured results for the various test parameters were compared to theoretical predictions from computer programs. Also the data were plotted on dimensionless coordinates and compared to several classical isothermal theories.

Author

N79-33475\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

### TRACTION DRIVE PERFORMANCE PREDICTION FOR THE JOHNSON AND TEVAARWERK TRACTION MODEL

Joseph L Tevaarwerk Washington Oct 1979 41 p refs (NASA-TP 1530 E 033) Avail NTIS HC A03/MF A01 CSCL 131

The fluid rheology model is used to investigate the traction behavior for typical traction drive contacts. The aspect ratio of the contact and the invariably present spin are investigated. Contacts with a low aspect ratio predict a superior performance.

in that they show less slip for the same degree of traction. Spin always has a diminishing effect on the traction at the same slip. At sufficiently high spin the model may be simplified to a limiting shear stress model. The conventional rigid plastic analysis applies here equally well.

N79-33476\*# National Agronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

# CORRELATION OF ASPERITY CONTACT TIME FRACTION WITH ELASTOHYDRODYNAMIC FILM THICKNESS IN A 20-MILLIMETER BORE BALL BEARING

John J. Coy. Washington. Oct. 1979. 21 p. refs (NASA-TP-1547; AVRADCOM-TR-79-26) Avail. NTIS HC A02/MF A01. CSCL 131

Elastohydrodynamic film thicknesses and asperity contact-time fractions were measured for a 20 mm bore ball bearing by using the capacitance and conductance techniques. The bearing was thrust loaded to 90. 445, and 778 N The corresponding maximum stresses on the inner race were 1.28, 2.09, and 2.45 GPa The test speed ranged from 400 to 15,000 rpm The test bearing was mist lubricated with a MIL-L-23699A turbine oil. The temperature was 27 C. The experimental results were correlated to give the percent film (no-contact-time fraction) as a function of measured film thickness. Measurements were made for three test series that represented the fest bearing in various conditions of run-in. The measurements show that the percent film changes with bearing run-in time. The experimental results agreed well with theoretical predictions based on surface trace analysis for a new bearing. For the run-in state, they agreed with previously reported experimental results. The results show that asperity contact existed at a film thickness-roughness ratio lambda of 6.0 or less for a new bearing. After run in, no asperity contact occurred at a lambda of 3.5 or greater

N79-33477\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## NASA GEAR RESEARCH AND ITS PROBABLE EFFECT ON ROTORCRAFT TRANSMISSION DESIGN

Erwin V Zaretsky, Denris P Townsend, and John J Coy. 1979. 19 p. refs. Presented at the Meeting on Helicopter Propulsion Systems, Williamsburg, Va. 6-8 Nov. 1979, sponsored by Am Helicopter Soc.

(NASA-TM 79292 E-235) Avail NTIS HC A02/MF A01 CSCL 13I

A79-10038 \* Liquid-cooling technology for gas turbines - Review and status, G. J. Van Fossen, Jr. (NASA, Lewis Research Center, Cleveland, Ohio, U.S. Army, Propulsion Laboratory, St. Louis, Mo.) and F. S. Stepka (NASA, Lewis Research Center, Cleveland, Ohio). In Intersociety Energy Conversion Engineering Conference, 13th. San Diego, Calif., August 20-25, 1978, Proceedings, Volume 1. (A79-10001-01-44). Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 262-271, 40 iefs.

After a brief review of past efforts involving the forced convection cooling of gas turbines, the paper surveys the state of the art of the liquid cooling of gas turbines. Emphasis is placed on thermosyphon methods of cooling, including those utilizing closed, open, and closed loop thermosyphons, other methods, including sweat, spray, and stator cooling, are also discussed. The more significant research efforts, design data, correlations, and analytical methods are mentioned and voids in technology are summarized.

ВЈ

A79-11545 \* # The practical impact of elastohydrodynamic lubrication. W. J. Anderson (NASA, Lewis Research Center, Cleveland, Ohio). Leeds-Lyon Symposium on Tribology, 5th, Leeds, England, Sept. 19-22, 1978, Paper. 13 p. 55 refs.

Elastohydrodynamic lubrication has had its most significant impact on, among all the types of concentrated contact mechanisms, rolling element bearings. EHL technology, through its inclusion in computer codes, now provides us with more effective methods for optimizing bearing design and for predicting bearing life, power loss, temperature and dynamic behavior. Bearing life prediction has advanced to a much more sophisticated level as compared to the calculation of fatigue life based on Lundberg-Palmgren theory. Application of elastohydrodynamics to gearing has, more or less, been limited to the calculation of pitch point film thicknesses. Techniques for calculating fi'm thicknesses over the entire range of tooth meshes for arbitrarily shaped guar teeth (noninvolute, spur, helical, etc.) need to be developed. Elastomer seals with both unidirectional and reciprocating motion offer a fruitful application for the elastohydrodynamics of low modulus materials. (Author)

...79-12850 \* Ceramics for the advanced automotive gas turbine engine - A look at a single shaft design. S. M. Nosek (NASA, Lewis Research Center, Cleveland, Ohio). In: Ceramics for high performance applications. II., Proceedings of the Fifth Army Materials. Technology. Conference, Newport, R.L., March. 21.25, 1977. (A79.12804.02-37). Chestnut Hill, Mass., Brook Hill Publishing. Co., 1978, p. 959.972.

A single-shaft regenerative design with a single-stage radial turbine is analyzed in terms of achievable fuel economy for the cases of both limited and unlimited turbine tip speed and regenerator inlet temperature. The 100-hip engine for a 3500 lib automobile is designed to use gasoline. Fuel economy data and operating parameters are presented for different values of turbine inlet temperatures, and turbine stress estimates and ceramic design stress estimates are discussed.

M.L.

A79-12851 \* Ceramic applications in the advanced Stirling automotive engine. W. A. Tomazic and J. E. Cairelli (NASA, Lewis Research Center, Cleveland, Ohio). In: Ceramics for high performance applications. II. Proceedings of the Fifth Army Materials Technology Conference, Newport, R.L., March 21-25, 1977. (A79-12804-02-37) Chestnut Hill, Mass., Brook Hill, Publishing Co., 1978, p. 973-987.

The requirements of the ideal Stirling cycle, as well as basic types of practical engines are described. Advantages, disadvantages, and problem areas of these Stirling engines are discussed. The potential for ceramic components is also considered Currently ceramics are used in only two areas, the air preheater and insulating tiles between the burner and the heater head. For the advanced Stirling engine to achieve high efficiency and low cost, the principal components are expected to be made from ceramic materials, including the fleater head, air preheater, regenerator, the burner and the power piston. Supporting research and technology programs for circumic component development are briefly described. (Author)

A79-14797 \* # Ion beam sputtering of fluoropolymers. J S Sovey (NASA, Lewis Research Center, Cleveland, Ohio) American Vacuum Society, National Vacuum Symposium, 25th, San Francis co. Calif., Nov. 28 Dec. 1, 1978, Paper. 14 p. 17 refs.

Etching and deposition of fluoropolymers are of considerable industrial interest for applications dealing with adhesion, chemical intertness, hydrophobicity, and dielectric properties. This paper describes ion beam sputter processing rates as well as pertinent characteristics of etched targets and films. An airon ion beam source was used to sputter etch and deposit the fluoropolymers PTFE, FEP and CTFE. Ion beam energy, current density, and target temperature were varied to examine effects on etch and deposition rates. The execution of the properties of the processing of the processing deposition that the processing deposition of the processing d

sputter target and film characteristics which were documented by spectral transmittance measurements, X-ray diffraction, ESCA, and SEM photomicrographs. (Author)

A79-14950 \* # Proposed design procedure for transmission shafting under fatigue loading. S. H. Loewenthal (NASA, Lewis Research Center, Cleveland, Ohio). *Illinois Institute of Technology, Annual Meeting of the National Conference on Power Transmission, 5th, Philadelphia, Pa., Nov. 7-9, 1978, Paper.* 10 p. 13 refs.

The B106 American National Standards Committee is currently preparing a new standard for the design of transmission shafting. A design procedure, proposed for use in the new standard, for computing the diameter of rotating solid steel shafts under combined cyclic benching and steady torsion is presented. The formula is based on an elliptical variation of endurance strength with torque exhibited by combined stress fatigue data. Fatigue factors are cited to correct specimen bending endurance strength data for use in the shaft formula. A design example illustrates how the method is to be applied. (Author)

A79-16663 \* Sputtering technology in solid film lubrication. T. Spalvins (NASA, Lewis Research Center, Cleveland, Ohio). In: International Conference on Solid Lubrication, 2nd, Denver, Colo., August 15-18, 1978, Proceedings. (A79-16651 04-27) Park Ridge, III., American Society of Lubrication Engineers, 1978, p. 109-117, 13 refs.

Current and potential sputtering technology is reviewed as it applies primarily to the deposition of MoS2, though such lubricants as WS2 and PTFE are also considered. It is shown by electron microscopy and surface sensitive analytical techniques that the lubricating properties of sputtered MoS2 films are directly influenced by the sputtering parameters selected (i.e., power density, pressure, sputter etching, dc-biasing, etc.), substrate temperature, chemistry, topography, and environmental conditions during the friction test. Electron micrographs and diffractograms of sputtered MoS2 films clearly show the resultant changes in film morphology which affect film adherence and frictional properties.

B.J.

A79-16664 Aplication of ESCA to the determination of stoichiometry in sputtered coatings and interface regions. D. R. Wheeler (NASA, Lewis Research Center, Cleveland, Ohio). In: International Conference on Solid Lubrication, 2nd, Denver, Colo., August 15-18, 1978, Proceedings. (A79-16651 04-27) Park Ridge, III., American Society of Lubrication Engineers, 1978, p. 118-127. 21 refs.

X-ray Photoelectron Spectroscopy (XPS) was used to characterize radiofrequency sputter deposited films of several refractory compounds. Both the bulk film properties such as purity and stoichiometry and the character of the interfacial region between the film and substrate were examined. The materials were CrB2, MoS2, Mo2C, and Mo2B5 deposited on 440C steel. It was found that oxygen from the sputtering target was the primary impurity in all cases. Blasing improves the film purity. The effect of biasing on film stoichiometry is different far each compound. Comparison of the interfacial composition with friction data suggests that adhesion of these films is improved if a region of mixed film and ino oxides can be formed.

A79-16678 \* Graphite-fiber-reinforced polyimide liners of various compositions in plain spherical bearings. H. E. Sliney and T. P. Jacobson (NASA, Lewis Research Center, Cleveland, Ohio), In: International Conference on Solid Lubrication, 2nd, Denver, Colo., August 15-18, 1978, Proceedings. (A79-16651-04-27) Park Ridge, III., American Society of Lubrication Engineers, 1978, p. 258-267, 20 refs.

Composites made of graphite-fiber-reinforced polyimide (GERPI) with a fiber-resin ratio (by weight) of about 1 were evaluated as molded outer-race lines in plain spherical bearings. Several compositions were examined two types of polyimide

(addition and condensation polymers), two types of graphite fiber (high and low modulus) and four powder additives (CdO, CdI2, (CF1...)n, and MoS2). Friction and wear were measured during oscillation at 25, 200, and 315 C. It is shown that all compositions provided good lubrication in dry air, that neither type of polymide or graphite fiber nor the additives gave a clear advantage, and that wear rates were slways higher during run-in, before conditions stabilized. It is concluded that GFRPI composites are self-lubricating under all but the most extreme moisture-free conditions at 25 C. The additives are helpful only with very high loads or extremely dry environments.

A79:20700 • Energy conservation through sealing technology, W. K. Stair (Tennessee, University, Knoxville, Tenn.) and L. P. Ludwig (NASA, Lewis Research Center, Cloveland, Ohio). (American Society of Lubrication Engineers, Annual Meeting, 33rd, Dearborn, Mich., Apr. 17-20, 1978.) Lubrication Engineering, vol. 34, Nov. 1978. p. 618-624, 12 refs.

Improvements in fluid film sealing resulting from a proposed research program could lead to an annual energy saving, on a national basis, equivalent to about 37 million bbl of oil or 0.3% of the total U.S. energy consumption. Further, the application of known sealing technology can result in an annual saving of an additional 10 million bbl of oil. The energy saving would be accomplished by reduction in process heat energy loss, reduction of frictional energy generated, and minimization of energy required to operate anciliary equipment associated with the seal system. In addition to energy saving lost effectiveness is further enhanced by reduction in maintenance is disminimization of equipment for collecting leakage and for nucleting environmental pollution standards. (Author)

A79-23229 \* \*\* Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus. II - Starved conjunction. B. J. Hamrock (NASA, Lewis Research Center, Cleveland, Ohio) and D. Dovison (Leeds University, Leeds, England). American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Minneapulis, Minn., Oct. 24-26, 1978, ASME Paper 78 Lub 1. 7, p. 12 refs. Members, \$1.50, nonmembers, \$3.00.

The study evaluates the effect of lubricant starvation on minimum film thickness in starved elliptical elastohydrodynamic conjunctions for materials of low elastic modulus. Lubricant starvation is studied simply by moving the inlet boundary closer to the center of the conjunction. A simple expression is presented for the dimensionless inlet boundary distance, this inlet boundary distance defines whether a fully flooded or a starved condition exists in the conjunction. A formula for the minimum film thickness under the starvation condition is derived. Contour plots of the pressure and tilm thickness in and around the contact are presented for both the fully flooded and starved lubrication conditions. It is shown that the inlet pressure contours become less circular and that the film thickness decreases substantially with increasing starvation severity.

A79-23235 \* W Stiffness of straight and tapered annular gas path seals. D. P. Fleming (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers and American Society of Lubrication Engineers, Junit Lubrication Conference, Minneapolis, Minn., Oct. 24-26, 1978, ASME Paper 78-Lub-18. 6 p. 18 refs. Members, \$1.50, nonmembers, \$3.00.

Radial stritness of annular (ring type) gas path seals is calculated for both constant clearance designs and tapered designs for which the inlet clearance is larger than the outlet clearance. Under some conditions a constant clearance seal can have a negative stiffness, this undesirable property can be completely eliminated by use of tapered seals. Leakage rates are only moderately higher in tapered seals.

(Author)

A79-23237 \* # Effect of geometry on hydrodynamic film thickness. D. E. Brewe (U.S. Army, Air Mobility Research and Development Laboratory, Cleveland, Ohio), B. J. Hamrock (NASA, Lewis Research Center, Cloveland, Ohio), and C. M. Taylor (Leeds University, Leeds, England). American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Minneapolis, Minn., Oct. 24-26, 1978, ASME Paper 78-Lub-24. 7 p. 18 refs. Members, \$1.50; nonmembers, \$3.00.

The influence of geometry on the isothermal hydrodynamic film separating two rigid solids was investigated. Pressure viscosity effects were not considered. The minimum film thickness is derived for fully rigoded conjunctions by using the Reynolds boundary conditions. It was found that the ininimum film thickness had the same speed, viscosity, and load dependence as Kapitza's classical solution. However, the incorporation of Reynolds boundary conditions resulted in an additional geometry effect. Solutions using the parabolic film approximation are compared with those using the exact expression for the film in the analysis. Contour plots are shown that indicate in detail the pressure developed between the solids.

(Author)

A79-23246 \* Filtration effects on ball bearing life and condition in a contaminated lubricant. S. H. Loewenthal (NASA, Lewis Research Center, Cleveland, Ohio) and D. W. Moyer (Tribon Bearing Co., Cleveland, Ohio). American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Minneapolis, Minn. Oct. 24-26, 1978, ASME Paper 78-Lub-34, 6 p. 20 refs. Members, \$1,50, nonmembers, \$3,00.

Ball bearings were fatigue tested with a noncontaminated MIL L-23699 lubricant and with a contaminated MIL L-23699 lubricant under four levels of filtration. The test filters had absolute particle removal ratings of 3, 30, 49, and 105 microns. Aircraft turbine engine contaminants were injected into the filter's supply line at a constant rate of 125 milligrams per bearing hour. Bearing life and running track condition generally improved with finer filtration. The experimental lives of 3 and 30 micron filter bearings were statistically equivalent, approaching those obtained with the noncontaminated lubricant bearings. Compared to these bearings, the lives of the 49-micron bearings were statistically lower. The 105 micron bearings experienced gross wear. The degree of surface distress, weight loss, and probable failure mode were dependent on fiftration level, with finer filtration being clearly beneficial. [Author]

A79 23251 \* Some loads limits and self-lubricating proper ties of plain spherical bearings with molded graphite fiberers forced polyimide liners to 320 C. H. E. Stiney (NASA, a.v.is. Research Center, Cleveland, Ohio). An encan Society of Latin atom Engineers and American Society of Mechanical Engineers, Joint Lubrication Conference, Mini-appoils, Mini-, Oct. 24.26, 1978. ASLE Preprint 78 LC 5C 2.5 p. Liefs.

A79 23267 Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves. 1. D. Wedeven (NASA, Lewis Research Center, Cleveland, Ohiol and C. Cusano (Illinois, University, Urbana, III.) American Society of Mechanical Engineers, and American Society of Mechanical Engineers, Joint Lubrication Conference, Minneapolis, Minn., Oct. 24-26, 1978, ASLE Preprint 78 LC 1A 1. 12 p. 32 refs.

Elastohydrodynamic (EHD) film thickness measurements using optical interferometry have been made of artificially produced dents and grooves under rolling and stiding conditions. These measurements are compared to stylus traces of the dent and groove profiles to determine the local deformation associated with micro-EHD pressure generation. The surface geometry, issuciated with the dentiand grooves is seen to become intonately involved in the individually deform the local surface geometry, particularly under stiding conditions. The rolling results have implications concerning surface.

initiated fatigue and the sliding results show clearly the EHD surface interactions that must occur prior to scufring failure. (Author)

A79-24035 \* # Analysis/dezign of strip reinforced random composites /strip hybrids/. C. C. Chamis and J. H. Sinclair (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Winter Annual Meeting, San Francisco, Calif., Dec. 10-15, 1978, Paper, 22 p. 6 refs.

Results are described which were obtained by applying advanced analysis methods and composite mechanics to a strip-reinforced random composite square panel with fixed ends. This was done in order to illustrate the use of these methods for the apriori assessment of the composite panel when subjected to complex loading conditions. The pane was assumed to be of E-Glass/Random Composite. The strips were \_\_umed to be of three advanced unidirectional composites to cover a range of low, intermediate, and high modulus stiffness. The panels were assumed to be subjected to complex loading to assess their adequacy as load-carrying members in auto body, aircraft engine nacelle, and windmill blade applications. The results show that strip hybrid panels can be several times more structurally efficient than the random composite base materials. Some of the results are presented in graphical form and procedures are described for use of these graphs as guides for preliminary design of strip hybrids.

A79-24121\* The use of ion beam cleaning to obtain high quality cold welds with minimal deformation. B. L. Sater and T. J. Moore (NASA, Lewis Research Center, Cleveland, Ohio). In Materials synergisms, Proceedings of the Tenth National Technical Conference, Kiamesha Lake, N.Y., October 17-19, 1978. (A79-24076-08-31). Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 548-560-9 refs.

This paper describes a variation of cold welding which utilizes an ion beam to clean mating surfaces prior to joining in a vaccim environment. High quality solid state welds were produced with minimal deformation. Due to experimental fixture limitation in applying pressure work has been limited to a few low yield strength materials. (Author)

A79-25103.\* Use of a nitrogen-argon plasmix to improve adherence of sputtered titanium carbide coatings on steel. W. A. Brainard and D. R. Wheeler (NASA, Lewis Research Center, Cleveland, Ohio). Journal of Vacuum Science and Technology, vol. 16. Jan. Feb. 1979. p. 31-36, 12 refs.

Friction and wear experiments on 440-C steel surfaces that had been RF sputtered with titanium carbide when a small percentage of nitrogen was added to the plasma were conducted. Xiray photoelectron spectroscopy, and Xiray diffraction were used to analyze the resultant coatings. Results indicate that a small partial pressure of nitrogen (about 0.5%) markedly improves the adherence, friction, and wear properties when compared with coatings applied on sputter-etched oxidized surfaces or in the presence of a small oxygen partial pressure. The improvements are related to the formation of an interface containing a mixture of the nitrides of pitanium and sign which are harder from their convesponding uxides.

A79-30398 \*\* Industrial potential, uses, and performance of sputtered and ion plated films. T. Spalvins (NASA, Lewis Research Center, Cleveland, Ohin). Society of Vacuum Coaters, Annual Technical Conference. 22nd. New Orleans, La., Mar. 28-30, 1979. Paper. 14 p. 16 refs.

The sputtering and ion plating technology is reviewed in terms of potential, uses, and performance. Sputtering is not regulated by classical thermodynamics and Gibb's phase rule relationships, thus eliminating the restrictions for materials combinations, and consequently making possible tailoring of coatings in any preferred chemical combination. The future of sputtered and ion plated films

for industrial applications is expected to depend primarily on greater comprehension of materials selection, and the utilization of the proper deposition parameters.

A.A.

A79-31368 Initial comparison of single cylinder Stirling engine computer model predictions with test results. R. C. Tew, Jr., L. G. Thisme, and D. Miao (NASA, Lewis Research Center, Cleveland, Ohio). Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26 Mar. 2, 1979, Paper 790327, 18 p. 15 refs.

A NASA developed digital computer code for a Stirling engine. modelling the performance of a single cylinder rhombic drive ground performance unit (GPU), is presented and its predictions are compared to test results. The GPU engine incorporates eight regenerator/cooler units and the engine working space is modelled by thirteen control volumes. The model calculates indicated power and efficiency for a given engine speed, mean pressure, heater and expansion space metal temperatures and cooler water injet temperature and flow rate. Comparison of predicted and observed powers implies that the reference pressure drop calculations underestimate actual pressure drop possibly due to oil contamination in the regenerator/cooler units, methane contamination in the working gas or the underestimation of mechanical loss. For a working gas of hydrogen, the predicted values of brake power are from 0 to 6% higher than experimental values, and brake efficiency is 6 to 16% higher, while for helium the predicted brake power and efficiency are 2 to 15% higher than the experimental. ALW

A.79.32414 \* // Elastomer grounted rotors - An alternative for smoother running turbomachin/ry. J. A. Tecza, S. W. Jones, A. J. Smalley (Mechanical Technology Inc., Latham, N.Y.), R. E. Cunning ham (NASA, Lewis Research Center, Cleveland, Ohio), and M. S. Darlow. American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San. Diego, Calif., Mar. 12.15, 1979, Paper 79-GT-149. 6 p. 25 refs. Members, \$1.50, nonmembers, \$3.00. NASA sponsored research.

This paper describes the design of elastomeric bearing supports for a rotor built to simulate the power turbine of an advanced gas turbine engine which traverses two bending critical speeds. The elastomer dampers were constructed so as to minimize rotor dynamic response at the critical speeds. Results are presented of unbalance response lests performed with two different elastomer materials These results showed that the resonances on the elastomer mounted rotor were well damped for both elactomer materials and showed lir ar response to the unbalance weights used for response testing A Sitional tests were performed using solid steel supports at either end (hand-mounted), which resulted in drastically increased sensitiv ity and nonlinear response, and with steel supports in one end of the rotor and the elastomer at the other, which yielded results which were between the soft, and hard-mounted cases. It is concluded that elastomenic supports are a viable alternative to other methods of mounting flexible rotors that damping was well in excess of predictions and that elastomers, supports are tolerant of small notor misalignments

A79.34993 Wide temperature spectrum self-lubricating chatings prepared by plasma spraying H. E. Stiney, INASA. Lewis Besseuth Center. Cleverand Utilin). Adventor Vacous. Society, and American Society for Metal, international Conference on Metallorgical Continues. San Press. East. Acre. 23.22, 1979. Prival. 8 to 7 ress.

Self-laborizating multicorreposed coalings, who is some at exvert a wide cause of operating countries is not decreased. If he coalings have been succeedingly, applied by maintaining, one, where never incommunity and maintained. They have been valuated of more and sear requirements, and maintained their have been valuated or the more and sear requirements, and maintained to a more applicable of the coalings are great registrate to a set of their helf-labor and fraction. Expenditured with order to be surrough greatments with a set of the property of the surrough and on the registration of the property of the search of the set of the property of the search of the set of the property of the search of the search of the property of the search of the search of the property of the search of the search of the property of the search of the search of the property of the search of th

of nichrome, glass and calcium fluoride are self-lubricating from about ±00 to 900 C, but give high friction at the lower temperatures The addition of silver to the coating composition improved the low temperature bearing properties and resulted in criatings which are will lubricating from disposenic temperatures to at least 870 C, they are therefore 'wide temperature spectrum,' self-lubricating composi-(Author)

A79-39805 \* # Diagnostics of wear in aeronautical systems, L. D. Wedeven (NASA, Lewis Research Center, Cleveland, Ohio). American Chemical Society, State-of-the-Ait Symposium on Corrosion and Wear, 15th, Washington, D.C., June 4-6, 1979, Paper, 4 n. 17 refs

The use of appropriate diagnostic tools for aircraft oil wetted components is reviewed, noting that it can reduce direct operating costs through reduced unscheduled maintenance, particularly in helicopter engine and transmission systems where bearing failure, are a significant cost factor. Engine and transmission wear modes are described, and diagnostic methods for oil and wet particle analysis, the spectrometric oil analysis program, chip detectors, ferrography, in-line oil monitor and radioactive isotope tagging are discussed, noting that they are effective over a limited range of particle sizes but compliment each other if used in parallel. Fine filtration can potentially increase time between overhauls, but reduces the offectiveness of conventional oil monitoring techniques so that alternative diagnostic techniques must be used. It is concluded that the development of a diagnostic system should be parallel and integral with the development of a mechanical system. AT

A79-39811 \* \* Two-dimensional random surface model for apperity contact in elastohydrodynamic lubrication. J. J. Coy (U.S. Army, Propulsion Laboratory, Cleveland, Ohio) and S. M. Sidik (NASA Lewis Research Center Cleveland Ohio). International Conference on Metrology and Properties of Engineering Surfaces, Leicester England, Apr. 18 20, 1979, Paper. 27 p. 23 refs.

Relations for the asper ty contact time fraction during elastohydrodynamic lubrication of a ball bearing are presented. The analysis is based on a two-dimensional random surface model, and actual profile traces of the bearing surfaces are used as statistical sample records. The results of the analysis show that transition from 90 percent contact to 1 percent contact occurs within a dimensionless him thickness range of approximately four to five. This thickness ratio is several times larger than reported in the literature where streamens and random surface models were used. It is shown that low pass filtering of the statistical records will bring agreement between the present results and those in the literature (Author)

#### N79 10423" Avco Lycoming Div Stratford Conn TRANSMISSION SEAL DEVELOPMENT Final Report, 1 Jul 1976 30 Apr 1977

Michael Brien. Oct. 1977. 41 p. refs. Sponsored in part by USAAMRDO

Contract NAS3 20045

NASA CR 135372 LYC 77 651 NTIS HC A03 MF A01 CSCL 11A

An experimental evaluation was performed on a high-speed 172.9 m s. 14.349 ft mini transmission seal of the synergistic type. During testing of the seal oil leakage occurred at positive bearing cavity pressures. Modification, were made in an attempt to enminate the leakage but none were completely successful. Leakage appears to be the result of questionable positioning of the sealing elements resulting in inadequate shaft contact by the bil side sealing element. This condition may be related to the consymmetrical shape of the elastomeric retainer and to dimensional changes caused by swelling of the elastomeric retainer from exposure to the sealed fluid. Indications of a speed dependent leakage characteristic were also observed Author

#### N79-11406'# Ford Motor Co Dearborn Mich AUTOMOTIVE STIRLING ENGINE DEVELOPMENT PRO GRAM Quarterly Technical Progress Report, Apr. 1978 Jun 1978

Jun 1978 96 p Sponsored by NASA (Contract EC-77 C 02 4396) CONS 4396-31 INASA CR 159436

Avail NTIS HC A05/MF A01 CSCL 13F

The third quarter (April-June 1978) effort of the Ford/DOE Automotive Stirling Engine Development Program is reported specifically Task 1 of that effort which is Fuel Economy Assessment. At the end of this quarter the total fourth generation fuel economy projection was 26.12 MPG (gasoline) with a confidence level of 44%. This represent an improvement of 66.4% over the baseline M. H fuel economy of 15.7 MPG. The confidence level for the original 20.6 MPG goal has been increased from 53% to 57% Engine 3X17 has accumulated a total of 213 hours of variable speed running. A summary of the individual sub tasks of Task 1 are given. The sub-tasks are grouped into two categories. Category 1 consists of those sub tasks which are directly related to fuel economy and Category 2 consists of those sub-tasks which are not directly related to fuel economy but are an integral part of the Task 1 effort

### N79-1140; \* AiResearch Mfg Co Phoenix Ariz MINI BRU L'S FOIL BEARING DEVELOPMENT Progress Report, 1 Jan 1978 3G Jan. 1978 F. X. Dobier and L. J. Miller Oct. 1978 150 p. refs

Contract NAS3 18517)

NASA CR 159442 AiResearch 31 2936 NTIS HC A07/MF A01 CSCL 13E

The analysis revealed the failure agent to be a combination of poor teflon coating adhesion a decrease in bearing sway space and, possibly lack of flushing flow through the bearing A change in Teflor coating vendors provided substantially improved coating quality and surface finish. The sway scace was increased and the cooling bleed flow was adjusted to flush the bearing. These changes were included in a test conducted in the WHL from 6 April to 22 May 1978 which resulted in the completion of 1006.9 hours of operation at temperature and load. Post test inspection revealed the bearings to be in excellent condition and capable of completing a much longer

#### N79 11408'# AiResearch Mfg Co Phoenix Anz ANALYSIS, DESIGN, FABRICATION AND TESTING OF THE MINI BRAYTON ROTATING UNIT (MINI BRU) VOLUME 1.

TEXT AND TABLES Final Report, Apr 1974 Jun 1978 F X Dobler et al. Oct. 1978, 219 p. refs. 2 Vol. Contract NAS3 18517

NASA CR 159441 Vol 1 AiResearch 31 2935 1: Avail NTIS HC A10/MF A01 CSCI 131

A 500 to 2100 watt power output Mini Brayton Rotating Unit (Mini BRU) was analyzed designed fabricated and rested Performance and test data for the various components is included. Components tested include the 2-12 in diameter compressor the 2.86 in diameter turbine the line alternator and the cantilevered foil type journal and thrust bearings. Also included are results on the fat ication of a C 103 turbine plenum nozzle assembly and on offgassing of the organic materials in the alter ator stator

#### N79 11409'# A Research Mtg. Co. Phoenix Any

ANALYSIS, DESIGN, FABRICATION AND TESTING OF THE MINI BRAYTON ROTATING UNIT (MIN. BRU) VOLUME 2 FIGURES AND DRAWINGS Final Report

F X Dobler Oct 1978 448 p. 2 Vo.

Contract NAS3 18517

NASA CR 159441 Vol.2 AiReseal # 31,2935.2 Avail N115 HC A19 MF A01 CSCL 131

This volume contains the figures and trawings reference in Volume 1

#79-14396\*# Battelle Columbus Labs. Ohio.

#### DETERMINATION OF LUBRICANT SELECTION BASED ON ELASTOHYDRODYNAMIC FILM THICKNESS AND TRAC-TION MEASUREMENT Finel Report

T. A. Dow and J. W. Kannel Jan 1979 113 p refs Sponsored in part by Army Aviation Research and Development Command. St Louis

(NASA-CR-159428) Avail NTIS HC A06/MF A01 CSCL

The project was conducted to aid in the development of an elastchydrodynamic specification for military lubricants. Experiments were conducted with a rolling disk apparatus designed to simulate a bearing or gear type contact. Measurements included lubricant film thickness, lubricant breakdown and traction for a range of loads, speeds, temperatures, and surface roughnesses. Several lubricants were used in the investigations including a traction fluid, two synthetic paraffinic lubricants and several lubricants conforming to MIL-L 7808 and 23699 specifications Recommendations regarding an EHD specification are included.

#### N79-17219\*# SKF Industries, Inc., King of Prussia, Pa. AIRCRAFT ENGINE SUMP FIRE MITIGATION, PHASE 2 Final Report

J W Rosenlieb Apr 1978 142 p refs (Contract NAS3-19436)

(NASA-CR-135379 NTIS A178T0071 Avail HC A07/MF A01 CSCL 21B

he effect of changes in the input parameters (air leakage Bow rate and temperature and lubricating oil inlet flow rate and temperature) over a specified range on the flammability conditions within an aircraft engine bearing sump was investigated. An analytical study was performed to determine the effect of various parameters on the generation rate of oil vapor from oil droplets in a hot air stream flowing in a cylindrical tube. The ignition of the vapor air mixture by an ignition source was considered. The experimental investigation demonstrated that fires would be ignited by a spark ignitor over the full range of air and oil flow rates and air temperatures evaluated. However, no fires could be ignited when the oil inlet temperature was maintained below 41.7 K (290 F) The severity of the fires ignited were found to be directly proportional to the hot air flow rate Reasonably good correlation was found between the mixture temperature in the sump at the ignitor location and the flammability limits as defined by flammability theory, thus a fairly reliable experimental method of determining flammable conditions within a sump was demonstrated. The computerized mathematical model shows that oil droplet size and air temperature have the greatest influence on the generation rate of oil vapor

#### N79-17221\*# Rockwell International Coro Canoga Park. Calif. SMALL HIGH PRESSURE LIQUID OXYGEN TURBOPUMP Final Report

A Csamor Oct 1978 156 p refs (Contract NAS3-17800)

NASA-CR 159509. Rt RD78-278) HC A08/MF A01 CSCL 131

A small, high-pressure LOX turbopump was designed. fabricated, and tested. The pump was of a single-stage, centrifugal type, power to the pump was supplied by a single-stage, partial-admission axial-impulse turbine Design conditions included an operating speed of 7330 rad/sec (70,000 rpm) pump discharge pressure of 2977 N/sq cm (4318 psial and a pump flowrate of 16.4 kg/s (36.21 ib/sec). The turbine was propelled by LOX/LH2 combustion products at 1041 K (1874 R) inlet temperature, and at a design pressure ratio of 1 424. Test data obtained with the turbopump are presented and mechanical performance is discussed

#### N79-17222\*# SKF Industries, Inc., King of Prussia, Pa. HIGH SPEED CYLINDRICAL ROLLER BEARING ANALYSIS. SKF COMPUTER PROGRAM CYBEAN. VOLUME 1: ANALYSIS Final Report

R J Kleckner and J Pirvics Jul 1978 108 p refs 2 Vol Contract NAS3-20068)

AL78P-022-Vol-1) NASA-CR-159460. NTIS HC A06/MF A01 CSCL 131

The CYBEAN (CYlindrical BEaring ANalysis) program was created to detail radially loaded, aligned and misaligned Cylindrical roller bearing performance under a variety of operating conditions The models and associated mathematics used within CYBEAN are described. The user is referred to the material for formulation assumptions and algorithm detail

N79-17223\*# SKF Industries, Inc., King of Prussia, Pa Technology Services Div

#### HIGH SPEED CYLINDRICAL ROLLER BEARING ANALYSIS. SKF COMPUTER PROGRAM CYBEAN. VOLUME 2: USER'S MANUAL Final Report

R J Kleckner and J Pirvics Jul 1978 141 p refs 2 Vol (Contract NAS3-20068)

NASA-CR-159461 AL78P023-Vol-2) HC A07/MF A01 CSCL 131

The CYBEAN (Cylindrical Bearing Analysis) was created to detail radially loaded, aligned and misaligned cylindrical roller bearing performance under a va. ety of operating conditions Emphasis was placed on detailing the effects of high speed. preload and system thermal coupling. Roller tilt, skew radial. circumferential and axial displacement as well as flange contact were considered. Variable housing and flexible out-of-round outer ring geometries, and both steady state and time transient temperature calculations were enabled. The complete range of elastohydrodynamic contact considerations, employing full and partial film conditions were treated in the computation of raceway and flange contacts. Input and output architectures containing guidelines for use and a sample execution are detailed

#### N79-17226\*# Israel Inst. of Tech. Haifa HYDRODYNAMIC EFFECTS IN A MISALIGNED RADIAL FACE SEAL Fine! Report

I Etsion Jul 1977 38 p refs Grant NsG-7317)

(NASA-CR-135228) Avail NTIS HC A03/MF AD1 CECL

Hydrodynamic effects in a flat seal having an angular misalignment are analyzed, taking into account the radial variation in seal clearance. An analytical solution for axial force, restoring moment, and transverse moment is presented that covers the whole range from zero to full angular misalignment. Both low pressure seals with cavitating flow and high pressure seals with full fluid film are considered. Strong coupling is demonstrated between angular misalignment and transverse moment which leads the misalignment vector by 90 degrees. This transverse moment, which is entirely due to hydrodynamic effects is a significant factor in the seal operating mechanism

#### N79-17228\*# Mechanical Technology, Inc., Latham, N. Y. EXPERIMENTS ON MULTIPLANE BALANCING USING A LASER FOR MATERIAL REMOVAL Final Report

Russett S Demuth Feb 1979 45 p (Contract NAS3-18520)

MTI-78TR69 NASA-CR-3105 HC A03/MF A01 CSCL 20E

The modifications of a flexible rotor system for two-plane laser balancing is described. Experimental testing of the laser material removal method for balancing through the first bending critical speed was demonstrated. The testing optical configuration and a neodymium glass laser system were assembled and calibrated for static and rotating material removal rates. The laser control computer program was con bined with the influence coefficient balancing process resulting in a completely automated data acquisition, laser and balancing system. The laser system-

rotor was balanced through the first bending critical speed using the laser material removal procedure :\_ apply trial weights and correction weights without stopping the rotor.

#### N79-23429°# Shaker Research Corp., Ballston Lake, N. Y. EXPERIMENTAL AND ANALYTICAL TOOLS FOR EVALUA-TION OF STIRLING ENGINE ROD SEAL BEHAVIOR Interim Report

A. I Krauter and H. S. Cheng (Northwestern Univ.) Feb. 1979 124 p refs

(Contracts DEN-3-22: ED 77-A-31-1040)

SRC-78TP-39) (NASA-CF-159543: NTIS HC AOS/MF AO1 CSCL 11A

The first year of a two year experimental and analytical program is reported. The program is directed at the elastohydrodynamic behavior of sliding elastomeric rod seals for the Stirling engine. During the year, experimental and analytical tools were developed for evaluating seal leakage, seal friction, and the fluid GY film thickness at the seal/cylinder interface

#### N79-24373\* # Mechanical Technology, Inc., Latham, N. Y. DEVELOPMENT OF PROCEDURES FOR CALCULATING STIFFNESS AND DAMPING OF ELASTOMERS IN ENGI NEERING APPLICATIONS. PART 5: ELASTOMER PER-FORMANCE LIMITS AND THE DESIGN AND TEST OF AN ELASTOMER DAMPER

J A Tecza, M S Darlow, and A J Smalley Feb 1979 144 p refs

(Contract NAS3 18546)

NASA-CR 159552 Rept 79TR30 Pt-5) NTIS HC A07/MF A01 CSCL 20K

Tests were performed on elastomer specimens of the material polybutadiene to d termine the performance limitations imposed by strain, temperature, and frequency. Three specimens were tested a shear speci on a compression specimen and a second compression specimen in which thermocouples were embedded in the elastomer buttons. Stiffness and damping were determined from all tests, and internal temperatures were recorded for the instrumented compression specimen. Measured results are presented together with comparisons between predictions of a thermo-viscoelastic analysis and the measured results. Dampers of polybutadiane and Viton were designed, built, and tested Vibration measurements were made and sensitivity of vibration to change in unbalance was also determined. Values for log decrement were extracted from the synchronous response curves Comparisons were made between measured sensitivity to unbalance and log decrement and predicted values for these quantities

#### N79-25392\*# Mechanical Technology, Inc. Latham, N.Y. T700 POWER TURBINE ROTOR MULTIPLANE MULTISPEED BALANCING DEMONSTRATION

G Burgess and R Rio Feb 1979 45 p refs

(Contract NAS3 18520)

MIT 79 TH-29) INASA CR 159586.

HC A03 MF ACT CSCI 20E

Research was conducted to demonstrate the ability of influence coefficient based multispeed balancing to control rotor vibration through bending criticals. Rotor dynamic analyses were conducted of the General Electric 1700 power turbine rotor The information was used to generate expected rotor behavior for optimal considerations in designing a balance rig and a balance technique. The roto: was successfully balanced 9500 rpm Uncontrollable coupling behavior prevented observations through the 16,000 rpm service speed. The balance technique is practical and with additional refinement it can meet production stand

### N79-25395°# Oak Ridge National Lab., Tenn. USER'S MANUAL FOR PRESTO: A COMPUTER CODE FOR THE PERFORMANCE OF REGENERATIVE STEAM

TURBINE CYCLES L. C. Fuller and T. K. Stovall Jun. 1979 93 p refs (NASA Order C-10669-D. Contracts W-7405-eng-26; DOE-40-666-77)

(NASA-CR-159540: ORNL-5547) NTIS HC A05/MF A01 CSCL 131

Standard turbine cycles for baseload power plants and cycles with such additional features as process steam extraction and induction and feedwater heating by external heat sources may be modeled Peaking and high back pressure cycles are also included. The code's methodology is to use the expansion line efficiencies, exhaust loss, leakages, mechanical losses, and generator losses to calculate the heat rate and generator output. A general description c the code is given as well as the instructions for input data preparation. Appended are two complete example

N79-31602\*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

#### DEVELOPMENT OF A PLASMA SPRAYED CERAMIC GAS PATH SEAL FOR HIGH PRESSURE TURBINE APPLICA-TIONS Final Report, 12 Sep. 1978 - 12 Apr. 1979

L T Shiembob and J. F. Hyland Sep. 1979 43 p.

(Contract NAS3-21390)

NASA-CR-159669. PWA-5633-11) NTIS

HC A03/MF A01 CSCL 11A

Development of the plasma sprayed graded, layered ZrO2/ CoCrAlY seal system for gas turbine engine blade tip seal application up to 1589 K (2400 F) surface temperature was continued. Methods of improvement of the cyclic thermal shock resistance of the sprayed zirconia seal system were investigated The most promising method, reduction of the ceramic thickness and metallic substrate stiffness were selected based upon potential and feasibility. Specimens were fabricated and experimentally evaluated to (1) substantiate the capacity of the geometry changes to reduce operating stresses in the sprayed structure; and (2) define the abradability, erosion, thermal shock and physical property characteristic for the sprayed ceramic seal system Thermal stress analysis was performed and correlated with thermal shock test results Author

#### N79-31603\*# Mechanical Technology, Inc., Latham, N. Y. DESIGN AND APPLICATION OF A TEST RIG FOR SUPER-CRITICAL POWER TRANSMISSION SHAFTS Final Report M Darlow and A Smalley Washington NASA Aug 1979 168 p reis

Contract NAS3 16824)

NASA CR 3155 MTI-78TR41) NIIS

HC A08/MF A01 CSCL 131

The design, assembly operational check-out and application of a test facility for testing supercritical power transmission shafts under realistic conditions of size, speed and torque are described. Alternative balancing methods and alternative damping mechanisms are demonstrated and compared. The influence of torque upon the unbalance distribution is studied, and its effect on synchronous vibrations is investigated. The feasibility of operating supercritical power transmission shafting is demonstrated, but the need for careful control, by balancing and damping, of synchronous and nonsynchronous vibrations is made clear. The facility was demonstrated to be valuable for shaft system development programs and studies for both advanced and current-production hardware

#### N79-32551°# Avco Lycoming D.v. Stratford, Conn. DEVELOPMENT OF SPIRAL GROOVE SELF ACTING SEALS FOR HELICOPTER ENGINES Final Report, 10 Jun. 1977 31 Dec. 1978

Michael OBrien Jun 1979 62 p Sponsored in part by Army Res and Technol Labs

(Contract NAS3-20795)

NASA-CR 159622. LYC-79-25) NTIS Avail HC A04/MF A01 CSCL 11A

A spiral-groove, self-acting face seal was rig tested at advanced gas turbine operating conditions to determine wear and leakage rates. The spiral-groove, self-acting geometry was located in the rotating seal seat. Seal component wear induced by start-stop operation was measured after subjecting the test seal to 176 start-stop cycles. Wear occurring during normal operation was documented throughout a 75-hour endurance test. Seal air leakage was also measured. During endurance operation, the seal was subjected to operating conditions bounded by the values surface speed - 244 m/s (800 ft/sec), air pressure - 148 N/sq cm abs (215 psia), and air temperature - 622 K (660 F). The post-test condition of the seal components was documented. Wear data is presented in tabular form, while seal air leakage is presented graphically, as a function of pressure and speed.

A79-12848 \* Ceranic blade attachments. G. S. Calvert and W. D. Carruthers (United Technologies 2000. Pratt and Whitney Aircraft Group, West Palm Beach, Fla.). In: Ceranics for high performance applications - II, Proceedings of the Fifth Army Materials Technology Conference, Newport, R.I., March 21-25, 1977. (A79-12804-02-37) Chestnut Hill, Mass., Brook Hill Publishing Co., 1978, p. 839-860. Contract No. NAS3-19715.

Studies under way on two concepts for producing a turbine rotor with ceramic blades and superalloy disks are discussed. One concept implicits hot-pressed silvon nitride blades and a compliant interlayer at the blade root end fitting whereas the second concept relies on a superplastic plastic forging technique to attach ceramic blades to the metal disk. This latter concept has been hot spin tested at 2250 F and 45,000 RPM for 50 hours in a vacuum spin pir. The fully bladed (30 blades) rotor survived this major test. (Author)

A79-16011 \* Design and test of a squeeze-film damper for a flexible power transmission shaft. M. S. Darlow and A. J. Smalley (Mechanical Technology, Inc., Latham, N.Y.). In: Topics in fluid film bearing and rotor bearing system design and optimization: Proceedings of the Design Engineering Conference, Chicago, Ill., April 17-20, 1978. (A79-16010 04-37) New York, American Society of Mechanical Engineers, 1978, p. 43-54. 7 refs. Contract No. NAS3-16824.

For a flexible shaft designed to pass through a number of bending critical speeds, a squeeze-film damper has been designed and tested. The damper properties were selected to provide control of all uritical speeds, while meeting additional constraints of high power transmission requirements and damper simplicity. The damper was fabricated and installed and its ability to control flexible shaft vibrations was demonstrated by the comparison of vibration amplitudes both with and without the damper.

(Author)

A79-23252 \* Development of surface coatings for air-lubricated, compliant journal bearings to 650 C. B. Bhushan and S. Grav (Mechanical Technology Inc., Latham, N.Y.) American Society of Lubrication Engineers and American Society of Mechanical Engineers, Joint Lubrication Conference, Minneapolis, Minn., Oct. 24.26, 1928, ASLE Preprint 78.LC-3C 1. 11 p. Contract No. N.AS.3.19427.

 A79-26985 \* Proof test criteria for thin walled pressure vessels. R. W. Finger (Boeing Aerospace Co., Seartle, Wash.). In: Application of fracture mechanics to design. (A79-26980 10-37) New York, Plenum Press, 1979, p. 83-110. 6 refs. Contract No. NAS3-18906.

A proof test criterion for assuring minimum service life requirements for aerospace pressure vessels is provided. The criteria proposed are based on the results of several experimental programs conducted on surface flaw specimens fabricated from 2219 aluminum base and weld metal. A description is presented of the stable crack growth behavior of surface flaws during loading. Conclusions derived from an experimental program are discussed. It is found that significant stable crack growth under increasing load can occur prior to failure. However, significant variability in results can be anticipated even when carefully controlled laboratory procedures are employed.

G.R.

A79-32351 \* # Laser balancing demonstration on a high-speed flexible rotor. R. S. DeMuth, R. A. Rio (Mechanical Technology, ITIG., Lotham, N.Y.), and D. P. Fleming (NASA, Lewis Research Center, Seals and Roter Dynamics Section, Cleveland, Ohio). American Society of Mechanical Engineers, Gus Tirchine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-67-55. 6 p. 6 refs. Members, \$1.50; nonmembers, \$3.00. Contract No. NAS3-18520.

This paper describes a flexible rotor system used for two-plane laser balancing and an experimental demonstration of the laser material removal method for balancing. A laboratory test rotor was modified to accept balancing corrections using a laser metal removal method while the rotor is at operating speed. The laser setup hardware required to balance the rotor using two correction planes is described. The test rig optical configuration and a neodymium glass laser were assembled and calibrated for material removal rates. Rotor amplitudes befue and after balancing, trial and correction weights, rotor speed during operation of laser, and balancing time were documented. The rotor was balanced through the first bending critical speed using the laser material removal procedure to apply trial weights and correction weights without stopping the rotor.

(Author)

A79-32412 \* # Nonsynchronous vibrations observed in a supercritical power transmission shaft. M. S. Darlow and E. S. Zorzi (Mechanical Technology, Inc., Latham, N.Y.). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-146. 9 p. 6 refs. Members, \$1.50: nonmembers, \$3.00. Contract No. NAS3-16824.

A flexible shaft is prone to a number of vibration phenomena which occur at frequencies other than synchronous with rotational speed. Nonsynchronous vibrations from several sources were observed while running a testing designed to simulate the operation of a supercritical power transmission shaft. The test rig was run first with very light external damping and then with a higher level of external damping, for comparison. As a result, the effect of external damping on the nonsynchronous vibrations of the test rig was observed. All of these nonsynchronous vibrations were of significant amplitude. Their presence in the vibration; spectra for a supercritical power transmission shaft at various speeds in the operating range indicates that very careful attention to all of the vibration spectra should be made in any supercritical power transmission shafting. This paper presents a review of the analysis performed and a comparison with experimental data. A thorough discussion of the observed nousynchronous (Author) whirl is also provided.

A79-32423 \* # An introduction to a unified approach to flexible rotor balancing. A. G. Parkinson (University College, London, England), A. J. Smalley, R. H. Badgley (Mechanical Technology, Inc., Latharn, N.Y.), and M. S. Darlow. American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-161. 14 p. 10 refs. Members, \$1.50; nonmembers, \$3.00. Contract No. NAS3-16824.

Two types of technique for flexible-rotor balancing are examined: the influence coefficient method, and the modal balancing method. Briefly, the influence coefficient method seeks those correction masses in a predetermined set of planes which will minimize measured vibration (readings) at a series of sensors and speeds, as predicted by influence coefficients relating vibration readings to mass additions; the influence coefficients are normally determined by a series of trial mass tests. The modal balancing method seeks to balance the rotor, one mode at a time, with a set of masses specifically selected not to disturb previously balanced lower modes, the sensitivity to this combination of masses is determined empirically by a series of trial mass tests. The two approaches are compared in supercritical-shaft balancing tests, and some common features are stressed for ultimate incorporation into a unified approach toward flexible-rotor balancing.

### 38 QUALITY ASSURANCE AND RELIABILITY

Includes product sampling procedures and techniques: and quality control.

N79-29530°# National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

A REVIEW OF ISSUES AND STRATEGIES IN NONDE-STRUCTIVE EVALUATION OF FIBER REINFORCED STRUCTURAL COMPOSITES

Alex Vary 1979 14 p refs Proposed for presentation at 11th Natl. SAMPE Tech. Conf., Boston, 13-15 Nov. 1979 (NASA-TM-79246; E-153) Avail: NTIS HC A02/MF A01 CSCL 14D

Techniques for quantitative assessment of the mechanical strength and integrity of fiber composites during manufacture and service and following repair operations are presented. Problems and approaches are discussed relative to acceptance criteria, calibrating standards, and methods for nondestructive evaluation of composites in strength-critical applications. Acousto-ultrasonic techniques provide the methods of choice in this area.

A79-39809 \* # Computer signal processing for ultrasonic attenuation and velocity measurements for material property characterizations. A. Vary (NASA, Lewis Research Center, Cleveland, Ohio). American Society for Nondestructive Testing and Southwest Research Institute, Symposium on Nondestructive Evaluation, 12th, San Antonio, Tex., Apr. 24-26, 1979, Paper. 18 p. 8 refs.

This report deals with instrumentation and computer programming concepts that have been developed for ultrasonic materials characterization. Methods that facilitate velocity and attenuation measurements are described. The apparatus described is based on a broadband, buffered contact probe using a pulse-echo approach for simultaneously measuring velocity and attenuation. Instrumentation, specimen condition, and signal acquisition and acceptance criteria are discussed. Typical results with some representative materials are presented. (Author)

N79-21410\* Martin Marietta Aerospace, Denver, Colo. DEFINITION OF MUTUALLY OPTIMUM NDI AND PROOF TEST CRITERIA FOR 2219 ALUMINUM PRESSURE VESSELS. VOLUME 1: METHODS

Fred R. Schwartzberg, Richard G. King, and Paul H. Todd, Jr. Feb. 1979 138 p refs 3 Vol. (Contract NAS3-17790)

(NASA-CR-135445) Avail: NTIS HC A07, MF A01 CSCL 14D

The requirements for proof testing and nondestructive respection of aluminum pressure vessels were discussed. The following conclusions are (1) lack-of-fusion wold defects are sufficiently tight in the as-welded condition to be considered undetectable; (2) proof-level loads are required to fully open lack-of-fusion word defects; (3) significant crack opening occurs at subproof levels so that an inspection enhancement loading treatment designed to avoid catastrophic failure is feasible; (4) currently used proof levels for 2219 pressure vossels are adequate for postproof inspection; (5) quantification of defect size and location using collimated ultrasonic pitch-catch techniques appears sufficiently feasible for tankage to warrant developmental work; (6) for short-time single-cycle pressure-vessel applications, costproof inspection is desirable; and (7) for long-term multiplecycle pressure-vessel applications, postproof inspection is essential for life assurance Author

N79-21411\* Martin Marietta Aerospace, Denver, Colo.
DEFINITION OF MUTUALLY OPTIMUM NDI AND PROOF
TEST CRITERIA FOR 2219 ALUMINUM PRESSURE
VESSELS. VOLUME 2: OPTIMIZATION AND FRACTURE STUDIES

Fred R. Schwartzberg, Charles Toth, Jr., Richard G. King, and Paul H. Todd, Jr. Feb. 1979 183 p refs 3 Vol. (Contract NAS3-17790)

(NASA-CR-135446) Avail: NTIS HC A09/MF A01 CSCL

Cortain behavioral aspects associated with fracture and crack extension that cannot be studied using other techniques were evaluated with the ultrasonic method. Characterization of collimated beam techniques showed that significant beam width reduction could be accomplished. Techniques for collimation are given. The crack-opening displacement-gage correction-factor study showed that displacement resulting from crack opening and that from plasticity could be readily differentiated. Crack closure studies using both ultrasonic and crack-opening displace--ont measurements showed an opening and closing behavior associated with load-unload curves. The results of this work were in general agreement with the closure concepts of Elber. Ultrasonic measurements used to study the nature of flaw extension characteristics associated with failure of the ligament between the flaw front and back surface showed that penetration could occur by an abrupt fracturing after subcritical growth or Author by continuous growth.

N79-21412\* Martin Marietta Aerospace, Denver, Colo. DEFINITION OF MUTUALLY OPTIMUM NDI AND PROOF TEST CRITERIA FOR 2219 ALUMINUM PRESSURE VESSELS. VOLUME 3: APPLICATIONS TO RAIL DEFECT EVALUATION

Fred R. Schwartzberg, Charles Toth, Jr., Richard G. King, and Paul H. Todd, Jr. Feb. 1979 35 p 3 Vol. (Contract NAS3-17790)

(NASA-CR-135447) Avail: NTIS HC A03/MF A01 CSCL 14D

The technique for inspection of railroad rails containing transverse fissure defects was discussed. Both pulse-echo and pitch-catch inspection techniques were used. The pulse-echo technique results suggest that a multiple-scan approach using varying angles of inclination, three-surface scanning, and dual-direction traversing may offer promise of characterization of transverse defects. Because each scan is likely to produce a reflection indicating only a portion of the defect, summing of the individual reflections must be used to obtain a reasonably complete characterization of the defect. The ability of the collimated pitch-catch technique to detect relatively small amounts of flaw growth was shown. The method has a problem in characterizing the portions of the defect near the top surface or web intersection. The work performed was a preliminary evaluation of the prospects for automated mapping of rail flaws. Author

### 39 STRUCTURAL MECHANICS

Includes structural element design and weight analysis; fetigue; and thermal stress.

For applications see 05 Aircraft Design, Testing and Performance and 18 Spececraft Design, Testing and Performance.

N78-10480° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STRAINRANGE PARTITIONING SEHAVIOR OF THE MICKEL-BASE SUPERALLOYS, RENE SO AND IN-100

G. R. Halford and A. J. Nachtigall In AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 14 p refs (For primary document see N79-10477 01-39)

Avail: NTIS HC A15/MF A01 CSCL 20K

A study was made to assess the ability of the method of strainrange partitioning (SRP) to both correlate and predict high temperature, low cycle fatigue lives of nickel-base superalloys for gas turbine applications. Baseline data from strain-controlled, low cycle fatigue tests were expressed in terms of the PP, PC, CP, and CC partitioned inelastic strainrange versus life relationships for coated and uncoated Rene' 80 at 1000 C, Gatorized (creep-formed)IN 100 at 760 C, and cast IN 100 at 925 C. The SRP i shown to correlate the cyclic lives of the baseline tests to within factors of nearly two. The partitioned strainrange versus life relationships for uncoated Rene' 80 and cast IN 100 were also determined from the ductility normalized-strainrange partitioning equations. These were used to predict the cyclic lives of the baseline tests. Predicted and observed cyclic lives agreed to within factors of nearly three.

N79-11433\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMAL-STRUCTURAL MISSION ANALYSES OF AIR-COOLED GAS TURBINE BLADES

Albert Kaufman and Raymond E. Gaugler 1978 13 p refs Proposed for presentation at the Intern. Gas Turbine Conf. San Diego, Calif., 11-15 Mar. 1979

(NASA-TM-78963; E-9720) Avail: NTIS HC A02/MF A01 CSCL 21E

Cyclic temperature and stress-strain states in cooled turbine blades were calculated for a simulated mission of an advanced technology aircraft engine. TACT1 (three dimensional heat transfer) and MARC (nonlinear structural analysis) computer programs were used to analyze impingement cooled airfoils, with and without leading-edge film cooling. Creep was the predominant damage mode, particularly around film cooling holes. Radially angled holes exhibited less creep than holes normal to surface. Beam-type analyses of all-impingement cooled airfoils gave fair agreement with MARC results for initial creep.

Author

N79-15326\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CELFE/NASTRAN CODE FOR THE ANALYSIS OF STRUCTURES SUBJECTED TO HIGH VELOCITY IMPACT

C. C. Chamis 1978 25 p refs Presented at 7th NASTRAN User's Colloq., Huntsville, Ala., 4-6 Oct. 1978 (NASA-TM-79048: E-9857) Avail: NTIS HC A02/MF A01 CSCL 20K

CELFE (Coupled Eulerian Lagrangian Finite Element)/
NASTRAN Code three-dimensional finite element code has the
capability for analyzing of structures subjected to high velocity
impact. The local response is predicted by CELFE and, for large
problems, the far-field impact response is predicted by NASTRAN. The coupling of the CELFE code with NASTRAN
(CELFE/NASTRAN code) and the application of the code to
selected three-dimensional high velocity impact problems are
described.

Author

N79-16326° National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
CODETRAN: COMPOSITE DURABILITY STRUCTURAL
ANALYSIS

C. C. Chamis and G. T. Smith 17 Nov. 1978 14 p refs Fresented at the 4th Conf. on Fibrous Composites in Struct. Design. San Diego, Calif. 14-17 Nov. 1978 (NASA-TM-79070; E-9837) Avail: NTIS HC A02/MF A01 CSCL 20K

CODSTRAN (COmposite Durability STRuctural ANalysis) is an integrated computer program being developed for the prediction of defect growth and fracture of composite structures subjected to service loads and environments. CODSTRAN is briefly described with respect to organization, capabilities and present status. Application of CODSTRAN current capability to a first composite laminate with a center slit which was subjected to axial tension loading predicted defect growth which is in good agreement with C-scan ultrasonic test records.

Author

N78-16300° National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL EVALUATION OF THE EFFECT OF INLET

DISTORTION ON COMPRESSOR BLADE VIBRATIONS
J. F. Lubomski 1979 17 p refs Presented at the Intern. Gas
Turbine Conf., San Diego, Calif., 12-15 Mar. 1979; sponsored
by Am. Soc. of Mechanical Engineers.

(NASA-TM-79066; E-9882) Avail: NTIS HC A02/MF A01 CSCL 20K

\*Compressor rotor strain gage data from an engine test conducted with an inlet screen distortion were reduced and analyzed. These data are compared to data obtained from the same engine without inlet pressure distortion to determine the net effect of the distortion on the vibratory response of the compressor blades. The results obtained are presented. Author

N79-17263°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CHARACTERISTICS OF AEROELASTIC INSTABILITIES IN TURBOMACHINERY - NASA FULL SCALE ENGINE TEST RESULTS

Joseph F. Lubomski 1379 21 p refs To be presented at the 4th Intern. Symp. on Air Breathing Eng., Lake Buena Vista, Fla., 1-6 Apr. 1979; sponsored by AIAA

(NASA-TM-79085; E-9908) Avail: NTIS HC A02/MF A01 CSCL 20K

Several aeromechanical programs were conducted in the NASA/USAF Joint Engine System Research Programs. The scope of these programs, the instrumentation, data acquisition and reduction, and the test results are discussed. Data pertinent to four different instabilities were acquired; two types of stall flutter, choke flutter and a system mode instability. The data indicates that each instability has its own unique characteristics. These characteristics are described.

G.Y.

N79-19415° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MEASUREMENT OF TRANSIENT STRAIN AND SURFACE TEMPERATURE ON SIMULATED TURBINE BLADES USING NONCONTACTING TECHNIQUES

Frederick D. Calfo and Frank G. Pollack Aug. 1978 18 p refs

(NASA-TM-78982; C-9180) Avail: NTIS HC A02/MF A01 CSCL 20K

Noncontacting techniques were used to measure strain and temperature in thermally cycled simulated turbine blades. An electro-optical extensometer was used to measure the displacement between parallel targets mounted on the leading edge of the blades throughout a complete heating and cooling cycle. An infrared photographic pyrometry method was used to measure blade steady state surface temperature. The blade was cyclically heated and cooled by moving it into and out of a Mach 1 hot-gas stream. Transient leading edge strain and steady state surface temperature distributions are presented for blades of three different configurations.

N78-20380\* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
INVESTIGATION OF WING SHIELDING EFFECTS ON CTOL

GINE NOISE

Harry E. Bloomer 1979 34 p refs Presented at the 5th Annual Aeroscoustics Conf., Seattle, 12-14 Mar. 1979; sponsored

(NASA-TM-79078: E-9895) Avail: NTIS HC A03/MF A01

CSCL 20K

A full scale engine wing shielding investigation was conducted at the Lewis Research Center using a 97,900-N (22,000 lb) thrust turbofan engine and a simulated wing section sized around a conventional-taks-off type four-engine narrow body airplane. Sound data were obtained for the wing placed at seven positions in a plane parallel to the engine axis, and were compared to data obtained without the wing at both take off and approach power. In addition, the engine was operated with and without extensive acoustic treatment, including a sonic inlet in order to evaluate wing shielding effectiveness with a highly suppressed engine. The wing shielding effectiveness was also calibrated using a 3.8 cm diam air nozzle as a second source. Results indicated that even though about 10 dB broad band shielding was achieved, the equivalent flyovor noise reduction was less than 3.0 EPNdB for most configurations.

N79-20391° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ME ASPECTS OF A FREE JET PHENOMENA TO 106 L/D IN A CONSTANT AREA DUCT

R. C. Hendricks 1979 41 p refs Proposed for presentation at the 15th Intern. Congr. of Refrig., Venice, 23-29 Sep. 1979; sponsored in part by the Intern. Inst. of Refrig. (NASA-TM-79050: E-9867) Avail: NTIS HC A03/MF A01

CSCL 20K

Under certain conditions, inlets with a Borda type geometry were shown to exhibit sufficiently strong separation effects to permit the working fluid to flow through tire duct as if it were a free jet. Mass limiting flow data and associated pressure profiles for tubes of 14, 53, 64, 73, and 105 L/D with a Borda type inlet were taken to determine bounds of the free jet phenomena. For a given tube roughness, the limits appear to be one dimensional and dependent only on inlet stagnation conditions. For smooth tubes the upper L/D boundary is related by P sub R roughly equal to CT to the 17th power and sub R, C roughly equal to 00017 (L/D) to the 2.5 power where F sub R = P/P sub c is reduced pressure and T sub R = T/T sub c is reduced temperature. The lower bound appears to be saturation conditions at the inlet. Similar free jet effects were found for fluid hydrogen indicating that fluid jetting may be common to all fluids. While limited data on surface roughness show a decrease in the upper L/D limit, nevertheless fluid jetting still occurred.

N79-20396\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF HIGH VELOCITY IMPACT ON HYBRID COMPOSITE FAN BLADES

C. C. Chamis and J. H. Sinclair 1979 17 p refs Presented at the 20th Structures, Structural Dyn. and Mater. Conf., St. Louis, Mo., 4-6 Apr. 1979: cosponsored by AIAA, ASME, ASCE, and AHS

(NASA-TM-79133: E-9979) Avail NTIS HC A02/MF A01 CSCL 21E

Recent developments in the analysis of high velocity impact of composite blades are described, using a computerized capability which consists of coupling a composites mechanics code with the direct-time integration features of NASTRAN. The application of the capability to determine the linear dynamic response of an interply hybrid composite aircraft engine fan blade is described in detail. The results also show that the impact stresses reach sufficiently high magnitudes to cause failures in the impact region at early times of the impact event.

N79-24369\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
COMPUTER SIGNAL PROCESSING FOR ULTRASONIC

ATTENUATION AND VELOCITY MEASUREMENTS FOR MATERIAL PROPERTY CHARACTERIZATIONS

Alex Vary 1979 19 p refs Presented at the 12th Symp on Nondestructive Evaluation, San Antionio, Tex., 24-26 Apr. 1979: cosponsored by the Am. Soc. for Nondestructive Testing and the Southwest Res. Inst. (NASA-TM-79180: E-048) Avail: NTIS HC A02/MF A01 CSCL

14D

Instrumentation and computer programming concepts that were developed for ultrasonic materials characterization are described. Methods that facilitate velocity and attenuation measurements are outlined. The apparatus scribed is based on a broadband, buffered contact probe using a pulse-echo approach for simultaneously measuring velocity and attenuation. Instrumentation, specimen condition, and signal acquisition and acceptance criteria are discussed. Typical results with some representative materials are presented.

N79-22565\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. EFFECT OF GRAIN ORIENTATION AND COATING ON THERMAL FATIGUE RESISTANCE OF A DIRECTIONALLY SOLIDIFIED SUPERALLOY (MAR-M 247)

P. T. Bizon, R. L. Dreshfield, and F. D. Calfo Apr. 1979 24 p.

(NASA-TM-79129; E-9968) Avail: NTIS HC A02/MF A01 CSCL 20K

The effect of off-axis directionally solidified (DS) grain growth on thermal fatigue life of Mar-M 247 alloy was evaluated. Uncoated conventionally cast as well as DS wedge bars were cycled in a burner rig between 1070 C and room temperature. The longitudinal axis and leading edge of the specimen coincided. As the angle between the specimen longitudinal axis and growth axis increased, the thermal fatigue life decreased for both the uncoated and aluminide-coated bars. Life increases of about 50 cycles for the DS conditions were attributed to coating. The decrease in thermal fatigue life with increasing angle is primarily attributed to the increase in modulus of elasticity with increasing angle and not to the intersection of DS grain boundaries with the specimen leading edge. The thermal fatigue cracks were observed to be transgranular in the DS material. Limited tensile and stress-rupture properties of conventionally cast and off-axis DS Mar-M 247 alloy are also presented.

N79-31619\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STRAINRANGE PARTITIONING LIFE PREDICTIONS OF THE LONG TIME METAL PROPERTIES COUNCIL CREEP-FATIGUE TESTS

J. F. Saltsman and G. R. Halford 1979 34 p refs Proposed for presentation at ti.4 Winter Ann. Meeting, N. Y., 2-7 Dec. 1979; sponsored by An. Soc. of Mech. Engr. (NASA-TM-79260: E-174) Avail: NTIS HC A03/MF A01

CSCL 20K

The method of strainrange partitioning is used to predict the cyclic lives of the Metal Properties Council's long time creep-fatigue interspersion tests of several steel alloys. Comparisons are made with predictions based upon the time- and cycle-fraction approach. The method of strainrange partitioning is shown to give consistently more accurate predictions of cyclic life than is given by the time- and cycle-fraction approach.

A79-10823 \* # Synthesis of blade flutter vibratory patterns using stationary transducers. A. Kurkov and J. Dicus (NASA, Lewis Research Center, Clevel and, Olive: American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Loraton, England, Apr. 9-13, 1978, Paper. 25 p. 9 refs.

Flutter frequency was determined-and rotor vibratory amplitude and phase distributions during flutter were reconstructed from stationary aerodynamic type measurements. A previously reported optical method for measuring blade-tip displacement during flutter was extended by means of digital analysis. Displacement amplitudes and phase angle were determined based on this method. For selected blades, spectral results were also obtained from strain gage measurements. The results from there three types of measurement were compared and critically evaluated. (Author)

A79-11543 \* # Acoustic emission testing of composite vessels under sustained loading. R. F. Lark and P. E. Moorhead (NASA, Lewis Research Center, Cleveland, Ohio). American Society for Testing and Materials, Symposium on Nondestructive Evaluation and Flaw Criticality for Composite Materials, Philadelphia, Pa., Oct. 10, 11, 1978, Paper. 24 p. 8 refs.

Acoustic emission (AE) tests have been conducted on small-diameter Kevlar 49/epoxy pressure vessels subjected to long-term sustained load-to-failure tests. Single-cycle burst tests were used as a basis for determining the test pressure in the sustained-loading tests. AE data from two vessel locations were compared. The data suggest that AE from vessel wall-mounted transducers is quite different for identical vessels subjected to the same pressure loading. AE from boss-mounted transducers yielded relatively consistent values. These values were not a function of time for vessel failure. The development of an AE test procedure for predicting the residual service life or integrity of composite vessels is discussed.

S.C.S.

A79-14954 \* # Review of the Agard S&M pane! evaluation program of the NASA-Lewis 'SRP' approach to high-temperature LCF life prediction. M. H. Hirschberg (NASA, 'swis Research Center, Cleveland, Ohio). NATO, AGARD, Meeting, 52nd, Cleveland, Ohio, Oct. 23-27, 1978, Paper. 10 p. 26 refs.

Twenty laboratories in six countries participated in this program, each testing its own materials of interest under its own laboratory conditions. In this way the results obtained provided validation of the Strainrange Partitioning (SRP) method for a wide range of materials and insured maximum usefulness to each of the participating laboratories. The first, very necessary step in the evaluation of any life prediction approach - assessing the ability of the method to predict life of simple laboratory specimens subjected to complex loading, was thereby taken. The culmination of this program was the Specialists Meeting that was held in Aalborg, Denmark in April of 1978. At that meeting the various investigators shared their findings, thus providing the basis for an in-depth evaluation of the SRP method. While the results were variable from laboratory to laboratory, most investigators agreed that the SRP method was a significant step toward life prediction in the presence of high temperature and cyclic stresses. (Author)

A79-15588 \* # Mode I analysis of a cracked circular disk subject to a couple and a force. B. Gross (NASA, Lewis Research Center, Cleveland, Ohio). In: Developments in theoretical and applied mechanics. Volume 9 - Proceedings of the Ninth Southeastern Conference, Nashville, Tenn., May 4, 5, 1978. (A79-15576 04-31) Nashville, Tenn., Vanderbilt University, 1978, p. 195-203. 8 refs.

Mode I stress intensity coefficients were obtained for an edge-cracked disk (round compact specimen). Results for this plane elastostatic problem, obtained by a boundary collocation analysis are presented for A/D ratios of 0.35 to 1, where A is the crack length and D is the disk diameter. The results presented are for two complementary types of loading. By superposition of these results the stress intensity factor for any practical load line location of a pin-loaded round compact specimen can be obtained. (Author)

A79-21298 \* # CELFE/NASTRAN Code for the analysis of structures subjected to high velocity impact. C. C. Chamis (NASA, Lewis Research Center, Cleveland, Ohio). NASA Marshall Space Flight Center, NASTRAN User's Colloquium, 7th, Huntsville, Ala., Oct. 4-6, 1978, Paper. 24 p. Contract No. NAS. 18908.

The CELFE (Coupled Eulerian Lagrangian Finite Element)/
NASTRAN Code three-dimensional finite element code has the capability for analyzing of structures subjected to high velocity impact.
The local response is predicted by CELFE and, for large problems, the far-field impact response is predicted by NASTRAN. The coupling of the CELFE code with NASTRAN (CELFE/NASTRAN code) and the application of the code to selected three-dimensional high velocity impact problems are described.

(Author)

A79-21831 \* Mode I analysis of a face cracked plate subjected to rotationally constrained end displacements. B. Gross (NASA, Lewis Research Center, Cleveland, Ohio). *International Journal of Fracture*, vol. 14, Dec. 1978, p. 623-631. 6 refs.

A79-29027 \* # Analysis of high velocity impact on hybrid composite fan blades. C. C. Chamis and J. H. Sinclair (NASA, Lewis Research Center, Composites and Structures Branch, Cleveland, Ohio). In: Structures, Structural Dynamics, and Materials Conference, 20th, St. Louis, Mo., April 4-6, 1979, Technical Papers on Structures and Materials. (A79-29002 11-39) New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 249-257. 6 refs. (AIAA 79-0783)

This paper describes recent developments in the analysis of high velocity impact of composite blades using a computerized capability which consists of coupling a composites mechanics code with the direct-time integration features of NASTRAN. The application of the capability to determine the linear dynamic response of an intraply hybrid composite aircraft engine fan blade is described in detail. The predicted results agree with measured data. The results also show that the impact stresses reach sufficiently high magnitudes to cause failures in the impact region at early times of the impact event.

(Author)

A79-30558 \* # Experimental evaluation of the effect of inlet distortion on compressor blade vibrations. J. F. Lubomski (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper. 15 p. 7 refs.

Compressor rotor strain gage data from an engine test conducted with an inlet screen distortion were reduced and analyzed. The data were compared to results obtained from the same engine without inlet pressure distortion to determine the net effect of the distortion on the vibratory response of the compressor blades. The effect of the distortion was found to be most prominent in the first three compressor stages, with the rotor speed establishing the period of the complex wave and, consequently, the frequencies of all the higher engine order excitations. At certain speeds it was observed that the complex pressure wave had the frequency content to excite a number of modes simultaneously, although the overall magnitudes were small and well within allowable stress limits.

A.A.

A79-37292 \* # CODSTRAN - Composite durability structural analysis. C. C. Chamis and G. T. Smith (NASA, Lewis Research Center, Cleveland, Ohio). Conference on Fibrous Composites in Structural Design, 4th, San Diego, Calif., Nov. 14-17, 1978, Paper. 13 p. 13 refs.

CODSTRAN (COmposite Durability STRucture ANalysis) a NASA Lewis Center computer program for the prediction of defect growth and fracture of composite structures when subjected to service loads is presented. Organization, capabilities and present status are discussed. Organizational aspects include executive, input, output, analysis and composite mechanics modules. Capabilities include: durability assessment of large structures and complex structural parts from composites, structural response due to static, cyclic, transient impact and thermal loads, and criteria for static, cyclic, and dynamic fracture. At the present state of development some of CODSTRAN's analysis capabilities include composite

mechanics, static failures, and lamination residual stresses. An application in which CODSTRAN is used to predict the defect growth in a flat specimen, with a center through-slit under tension is studied. When completed, CODSTRAN will account for geometry and material nonlinearities, environmental effects as well as static, cyclic and dynamic fracture.

M.E.P.

A79-39812 \* # Mode 1 crack surface displacements for a round compact specimen subject to a couple and force. B. Gross (NASA, Lewis Research Center, Cleveland, Ohio). American Society for Testing and Materials, National Symposium on Fracture Mechanics, 12th, St. Louis, Mo., May 21-23, 1979, Paper. 10 p. 5 refs.

Mode I displacement coefficients along the crack surface are presented for a radially cracked round compact specimen, treated as a plane elastostatic problem, subjected to two types of loading; a uniform tensile stress and a nominal bending stress distribution across the net section. By superposition the resultant displacement coefficient or the corresponding influence coefficient can be obtained for any practical load location. Load line displacements are presented for A/D ratios ranging from 0.40 to 0.95, where A is the crack length measured from the crack mouth to the crack tip and D is the specimen diameter. Through a linear extrapolation procedure crack mouth displacements are also obtained. Experimental evidence shows that the results of this study are valid over the range of A/D ratios analyzed for a practical pin loaded round compact specimen.

A79-39813 \* # On the equivalence between semiempirical fracture analyses and R-curves. T. W. Oranga (NASA, Lewis Research Center, Cleveland, Ohio). American Society for Testing and Materials, National Symposium on Fracture Mechanics, 12th, St. Louis, Mo., May 21-23, 1979, Paper. 32 p. 10 refs.

The relationships between several semiempirical fracture analyses (Brockrath and Glassco, 1974; Newman, 1973; Kuhn, 1968; Orange, 1971; Feddersen, 1971) and the R-curve concept of fracture mechanics are examined. Some characteristics of the R-curve concept when applied to finite-width specimens are reviewed, and conditions for equivalence between a semiempirical analysis (SEFA) and an R-curve are derived. The relationship between R-curves and SEFAs is studied for a hypothetical material. It is shown that for each SEFA there is an equivalent R-curve, the magnitude and shape of which are determined by the SEFA formulation and parameters, and which predicts precisely the same relationship between fracture stress and original crack length. A given SEFA correlates residual strength data closely if its equivalent R-curve closely matches the actual R-curve of the material studied. The SEFA given by Newman is found to yield best results for the hypothetical case considered. Equivalent R-curves for real materials are developed using data from the literature. C.K.D.

N79-10479°# TRW, Inc., Cleveland, Ohio. Materials Technology

A STRAINRANGE PARTITIONING ANALYSIS OF LOW CYCLE FATIGUE OF COATED AND UNCOATED RENE SO C. S. Kortovich and A. A. Sheinker In AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 23 p refs Sponsored in part by Army Air Mobility Res. and Develop. Lab. (For primary document see N79-10477 01-39)

(Contract NAS3-17830)

Avail: NTIS HC A15/MF A01 CSCL 20K

A strainrange pertitioning analysis was conducted on ultrahigh vacuum, strain-controlled, low-cycle fatigue behavior of uncoated and aluminide coated Rene' 80 nickel-base superalloy at 1000 C (1832 F) and 871 C (1600 F). The results indicated little effect of coatiny or temperature on the fatigue resistance. There was, however, a significant effect on fatigue life when creep was introduced into the strain cycles. The effect of this creep component was analyzed in terms of the method of strainrange partitioning.

Author

N78-13468°# Settelle Columbus Labe., Ohio.
STRESS ANALYSIS FOR STRUCTURES WITH SURFACE
CRACKS Final Report
J. C. Bell Aug. 1978 152 p refs
(Contract NAS3-21020)
(NASA-CR-159400) Avail: NTIS HC A08/MF A01 CSCL

Two basic forms of analysis, one treating stresses around arbitrarily loaded circular cracks, the other treating stresses due to loads arbitrarily distributed on the surface of a helf space, are united by a boundary-point least squares method to obtain analyses for stresses fir m surface cracks in places or bars. Calculations were for excugh cases to show how effects from the crack vary with the depth-to-length ratio, the fractional penetration ratio, the obliquity of the load, and to some extent the fractional span ratio. The results include plots showing stress intensity factors, stress component distributions near the crack, and crack opening displacement patterns. Favorable comparisons are shown with two kinds of independent experiments, but the main method for confirming the results is by wide checking of overall satisfaction of boundary conditions, so that external confirmation is not essential. Principles involved in designing analyses which promote dependability of the results are proposed and illustrated.

A.R.H.

N79-13408" | Bettelle Columbus Labs., Ohio.
USER'S MANUAL FOR FRACSD: SUPPLEMENT TO
REPORT ON STRESS ANALYSIS FOR STRUCTURES WITH
SURFACE CRACKS
J. C. Bell, A. T. Hopper, and P. A. Hayes Aug. 1978 125 p

(Contract NAS3-21020)

(NASA-CR-159401) Avail: NTIS HC A06/MF A01 CSCL 20K

The FRAC3D computer program, designed for use in analyzing streeses in structures (including plates, bers, or blocks) which may contain part-circular surface cracks or embedded circular cracks is described. Instructions are provided for preparing input, including that for the supporting programs LATTICE and MATSOL as well as for FRAC3D. The course of a substantial illustrative calculation is shown with both input and output. The formulas underlying the calculations are summarized and related to the Pubroutines in which they are used. Many issues of strategy in using this program for analysing stresses around surface cracks are eluc/deted.

N79-18343\*# Massachusetts Inst. of Tech., Cambridge. Aeroelastic and Structures Research Lab.

USER'S GUIDE TO COMPUTER PROGRAMS JET 5A AND CIVM-JET 5B TO CALCULATE THE LARGE ELASTIC-PLASTIC DYNAMICALLY-INDUCED DEFORMATIONS OF MULTILAYER PARTIAL AND/OR COMPLETE STRUCTURAL RINGS

Richard W. H. Wu, Thomas R. Stagliano, Emmett A. Witmer, and Robert L. Spilker Nov. 1978 381 p. refs. (Grant NGR-22-009-339)

(NASA-CR-159484; ASRL-TR-154-10) Avail: NTIS HC A17/MF A01 CSCL 20K

These structural ring deflections lie essentially in one plane and, hence, are called two-dimensional (2-d). The structural rings may be complete or partial; the former may be regarded as representing a fragment containment ring while the latter may be viewed as a 2-d fragment-deflector structure. These two types of rings may be either free or supported in various ways (pinned-fixed, locally clamped, elastic-foundation supported, mounting-bracket supported, etc.). The initial geometry of each ring may be circular or arbitrarily curved; uniform-thickness or variable-thickness rings may be analyzed. Strain-hardening and strain-rate effects of initially-isotropic material are taken into account. An approximate analysis utilizing kinetic energy and momentum conservation relations is used to predict the after-impact velocities of each fragment and of the impact-affected region of the ring; this procedure is termed the collision-imparted velocity method (CIVM) and is used in the CIVM-JET 5 B program. This imparted-velocity information is used in conjunction with a finite-element structural response computation code to predict the transient, large-deflection, elastic-plastic responses of the ring. Similarly, the equations of motion of each fragment are solved in small steps in time. Provisions are made in the CIVM-JET 5B code to analyze structural ring response to impact attack by from 1 to 3 fragments, each with its own size, mass, translational velocity components, and rotational velocity. The effects of friction between each fragment and the impacted ring are included.

N79-19414° California Univ. at Los Angeles.
NONLINEAR EQUATIONS OF EQUILIBRIUM FOR ELASTIC
HELICOPTER OR WIND TURBINE BLADES UNDERGOING
MODERATE DEFORMATION Final Report
Avin Rosen and Peretz P. Friedmann Dec. 1978 104 p refs
(Grant NaG-3062; Contract E(49-26)-1028) NASA-CR-159478; UCLA-ENG-7718; DOE/NASA/3082-78/1) Avail: NTIS HC A06/MF A01 CSCL

A set of nonlinear equations of equilibrium for an elastic wind turbine or helicopter blades are presented. These equations are derived for the case of small strains and moderate rotations (slopes). The derivation includes several assumptions which are carefully stated. For the convenience of potential users the equations are developed with respect to two different systems of coordinates, the undeformed and the deformed crordinates of the blade. Furthermore, the loads acting on the blade are given in a general form so as to make them suitable for a variety of applications. The equations obtained in the study are compared with those obtained in previous studies.

N79-20382°# California Univ. at Los Ang NONLINEAR EQUATIONS OF EQUILIBRIUM FOR ELASTIC HELICOPTER OR WIND TURBINE BLADES UNDERGOING MODERATE DEFORMATION Final Report

Aviv Rosen and Peretz P. Friedman, Dec. 1978 105 p refs Prepared for DOE

(Grant NaG-3082; Contract E(49-26)-1028)

20K

(NASA-CR-159478: DOE/NASA/3082-78/1: UCLA-ENG-7718) Avail: NTIS HC A08/MF A01 CSCL 20K

The equations are derived for the case of small strains and moderate rotations (slopes). For the convenience of potenial users the equations are developed with respect to two different systems of coordinates, the undeformed and the deformed coordinates of the blade. The loads acting on the blade are given in a general form so as to make them suitable for a variety of applications. Author

N79-26429°# Syracuse Univ., N. Y. George Sachs Fracture and Fatigue Research Lab. A LITERATURE REVIEW ON FATIGUE AND CREEP

INTERACTION

Wen-Ching Chen [1978] 41 p refs

(Grant NGR-33-022-157)

(NASA-CR-135305: MTS-HWL-4116-776) Avail: NTIS HC A03/MF A01 CSCL 20K

Life-time prediction methods, which are based on a number of empirical and phenomenological relationships, are presented. Three aspects are reviewed: effects of testing parameters on high temperature fatigue, life-time prediction, and high temperature MMM fatigue crack growth.

N79-31627°# Lehigh Univ., Bethlehem, Pa. Inst. of Fracture and Solid Mechanics

NORMAL AND RADIAL IMPACT OF COMPOSITES WITH EMBEDDED PENNY-SHAPED CRACKS Interim Report

G. C. Sih Feb. 1979 54 p refs (Grant NsG-3179)

(NASA-CR-15953R

IFSM.79.99) Avail

HC AO4/MF AO1

A method is developed for the dynamic stress analysis of a layered composite containing an embedded penny-shaped crack and subjected to normal and radial impact. The material properties of the layers are chosen such that the crack lies in a layer of matrix material while the surrounding material possesses the average elastic properties of a two-phase medium consisting of a large number of fibers embedded in the matrix. Quantitatively, the time-dependent stresses near the crack border can be described by the dynamic stress intensity factors. Their magnitude depends on time, on the material properties of the composite and on the relative size of the crack compared to the composite local geometry. Results obtained show that, for the same material properties and geometry of the composite, the dynamic stress intensity factors for an embedded (penny-shaped) crack reach their peak values within a shorter period of time and with a lower magnitude than the corresponding dynamic stress intensity factors for a through-crack. Author

A79-27938 \* Stresses from arbitrary loads on a circular crack. J. C. Bell (Battelle Columbus Laboratories, Columbus, Ohio). International Journal of Fracture, vol. 15, Feb. 1979, p. 85-104. 18 refs. Research supported by the Battelle Memorial Institute and Bell Aerospace Co.; Contracts No. F33615-72-C-1739; No. NAS3-17760.

An inclusive theory is developed for stresses and displacements due to arbitrarily distributed normal and tangential loads acting on a circular crack in an infinite body. The representation chosen for the boundary conditions leads to solutions expressed as series of Besselfunction integrals of a class quite susceptible to further analysis and to rapid evaluation on modern computers. The load coefficients which appear in all the solution series bear intelligible interpretation, and stress intensity factors are related to them by simple formulas. The inclusiveness and tractability of the solutions qualify this theory to be a useful part of analyses for cracks in finite bodies in which the effective crack loads can assume many patterns.

### 43 EARTH RESOURCES

Includes remote sensing of earth resources by aircraft and spacecraft; photogrammetry; and serial photography. For instrumentation see 35 Instrumentation and Photography.

N78-13472° | National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

APPLICATION OF MULTISPECTRAL SCANNER DATA TO THE STUDY OF AN ABANDONED SURFACE COAL MINE Ernie W. Spisz Nov. 1978 80 p refs Original contains color illustrations.

(NASA-TM-78912; E-9647) Avail: NTIS HC A05/MF A01 CSCL OBI

The utility of aircraft multispectral scanner data for describing the land cover features of an abendoned contour-mined coal mine is considered. The data were obtained with an 11 bend multispectral scanner at an attitude of 1.2 kilometers. Supervised, rasximum-likelihood statistical classifications of the data were made to establish land-cover classes and also to describe in more datail the barren surface features as they may pertain to the reclamation or restoration of the area. The scanner data for the surface-water areas were studied to establish the variability and range of the spectral signatures. Both day and night thermal images of the area are presented. The results of the study show that a high degree of statistical separation can be obtained from the multispectral acanner data for the various land-cover features.

G.G.

N79-22589° National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A COMPARISON OF MEASURED AND CALCULATED UPWELLING RADIANCE OVER WATER AS A FUNCTION OF SENSOR ALTITUDE

Thom A. Coney and Jack A. Selzman. 1979. 19 p. refs. Presented at the 13th Intern. Symp. on. Remote. Sensing of Environment, Ann. Arbor. Mich., 23-27. Apr. 1979; sponsored by Mich. Univ. (NASA-TM-79147; E-003). Avail. NTIS. HC A02/MF A01. CSCL 08H.

A comparison is made between remote sensing data measured over water at altitudes ranging from 30 m to 15.2 km and data calculated for corresponding altitudes using surface measurements and an atmospheric radiative transfer moder. Data were acquired on June 22, 1978 in Lake Erie, a cloudless, calm, near haze free day. Suspended solids and chlorophyll concentrations were 0.59 + or - 0.02 mg/1 and 2.42 + or - 0.03 micrograms/1 respectively throughout the duration of the experiment. Remote sensor data were acquired by two multispectral scanners each having 10 bands between 410 nm and 1040 nm. Calculated and measured nadir radiances for altitudes of 152 m and 12.5 km agree to within 16% and 14% respectively. The variation in measured radiance with look angle was poorly simulated by the model it was concluded that an accurate assessment of the source of error will require the clusion in the analysis of the contributions made by the sea ate and Author specular sky reflectance

N79-22590\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FEASIBILITY OF DETERMINING FLAT ROOF HEAT LOSSES USING AERIAL THERMOGRAPHY

Robert L. Bowman and John R. Jack. 1979. 17. p. refs. Presented at the 13th Intern. Symp. on Remote Sensing of Environment, Ann. Arbor, Mich., 23-27. Apr. 1979; sponsored by Mich. Univ. (NASA-TM-79152; E-9981). Avail. NTIS. HC A02/MF A01. CSCL. 138.

The utility of aerial thermography for determining rooftop heat losses was investigated experimentally using several completely instrumented test roofs with known thermal resistances. Actual rooftop heat losses were obtained from overflights at an attitude of 305 m. In general, the remotely determined roof surface temperatures agreed very well with those obtained.

from ground measurements. The roof heat losses calculated using the remotely determined roof temperature agreed to within 17% of those calculated from 1/R delta T using ground measurements. However, this agreement may be fortuitous since the convective component of the heat loss is sensitive to small changes in roof temperature and to the average heat transfer coefficient used, whereas the radiative component is less sensitive. This, at this time, it is felt that an acceptable quantitative determination of roof heat losses using serial thermography is only feasible when the convective term is accurately known or minimized. The sensitivity of the heat loss determination to environmental conditions was also evaluated. The analysis showed that the most reliable quantitative heat loss determinations can probably be obtained from serial thermography taken under conditions of total cloud cover with low wind speeds and at low ambient Author temperatures

A79-36537 \* # Radar image processing of real aperture SLAR data for the detection and identification of iceburg and ship targets. J. G. Marthaler (U.S. Coast Guard, Office of Research and Development, Washington, D.C.) and J. E. Heighway (NASA, Lewis Research Center, Applications Div., Cleveland, Ohio). In: Canadian Symposium on Remote Sensing, 5th, Victoria, British Columbia, Canada, August 28-31, 1978, Proceedings. (A79-36486 15-43) Ottawa, Canadian Aeronautics and Space Institute, 1979, p. 483-494.

An icebery detection and identification system consisting of a moderate resolution Side Looking Airborne Radar (SLAR) interfaced with a Radar Image Processor (RIP) based on a ROLM 1664 computer with a 32K core memory updatable to 64K is described. The system can be operated in high- or low-resolution sampling modes. Specifically designed algorithms are applied to digitized signal returns to provide automatic target detection and location, geometrically correct video image display and data recording. The real aperture Motorola AN/APS-94D SLAR operates in the X-band and is tunable between 9.10 and 9.40 GHz; its output power is 45 kW peak with a pulse repetition rate of 750 pulses per hour. Schematic diagrams of the system are provided, together with preliminary test data.

C.K.D.

A79-51095 \* # Feasibility of determining flat roof heat losses using aerial thermography. R. L. Bowman and J. R. Jack (NASA, Lewis Research Center, Cleveland, Ohio). University of Michigan, International Symposium on Remote Sensing of Environment, 13th, Ann Arbor, Mich., Apr. 23.27, 1979. Paper. 15 p. 8 refs.

The utility of aerial thermography for determining rooftop heat losses is investigated. Actual rooftop heat losses were obtained both from inisitu instrumentation of test roofs with known thermal resistances and aerial thermography obtained from overflights at ail altitude of 305 m. It is found that the roof heat losses calculated using the remotely determined roof temperature agreed to within 17% of those calculated from ground measurements. However it is noted that an acceptable quantitative determination of roof heat losses using aerial thermography is only feasible when the convective term is accurately known or minimized. In addition, the sensitivity of the heat loss determination to environmental conditions is also evaluated. Finally, the unaltysis shows that the most reliable determinations can probably be obtained under conditions of total cloud cover with low wind speeds and at low ambient temperatures.

N79-12524°# Environmental Research Inst. of Michigan, Ann Arbor: Infrared and Optics Div

ATMOSPHERIC TRANSFORMATION OF MULTISPECTRAL REMOTE SENSOR DATA Pinel Report, 2 Nov. 1978 - 1 Oct. 1977

Robert E Turner, Principal investigator Nov 1977 128 p. refs ERTS

(Contract NAS3-20483)

(E79-10006, NASA-CR-135338, ERIM-126100-3-F) Avail NTIS HC A07/MF A01 CSCL 20F

The author has identified the following significant results

The effects of earth's atmosphere were accounted for, and a simple algorithm, based upon a radiative transfer model, was developed to determine the radiance at earth's surface free of atmospheric effects. Acctal multispectral remote sensor data for Lake Erie and associated optical thickness data were used to demonstrate the effectiveness of the atmospheric transformation algorithm. The basic transformation was general in nature and could be applied to the large scale processing of multispectral aircraft or sotellite remote sensor data.

# 44 ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e.g., fuel cells and batteries, global sources of energy; fossil fuels, geophysical conversion, hydroelectric power; and wind power

For related information see also 07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels, and 85 Urban Technology and Transportation.

N79-11467\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## SOLAR CELLS HAVING INTEGRAL COLLECTOR GRIF &

John C Evans Jr., inventor (to NASA) Issued 1 Aug 1173 7 p. Filed 6 Jun 1977 Supersedes N77-24593 (15 - 15, p. 2011)

NASA-Case LEW 12819 1, US Patent 4.104.084

US Patent Appl SN 803823 US Patent Class 136-89CC

US-Patent Class-136-895J. US Patent-Class-357-15

US-Patent Class 357-16. US Patent Class-357-30

US Patent Class 357-65 US Patent Class-357-67) Avail US Patent Office CSCL 10A

A heterojunction or Schottky barrier photovoltaic device is described, comprising a conductive base metal layer. A back surface field reginn was formed at the interface between the device and the base metal layer, a transparent, conductive mixed metal oxide layer in integral contact with the nitype layer of the heterojunction or Schottky barrier device. A metal alloy grid network was included. An insulating layer prevented electrical foundation between the conductive metal base layer and the transparent conductive metal oxide layer.

Official Gazette of the U.S. Patent Office

N79-11468\* National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

## APPLICATION OF SEMICONDUCTOR DIFFUSANTS TO SOLAR CELLS BY SCREEN PRINTING Patent

John C Evans Jr. Henry W. Brandhorst Jr. George A. Mazaris, and Larry R. Scudder, inventors (to NASA). Issued 1. Aug. 1978. 5 p. Filed 20. May 1977. Supersedes N77 24589 (15. 15. p. 2010).

INASA Case LEW 12775 1 US Fatent 4 104 091

US Patent Appl SN 799026 US Patent Class 148 188

US Patent Class 29 572 US Patent Class 136 89

US Patent Class 427-75) Avail US Patent Office CSCL 10A Diffusants were applied onto semiconductor solar cell substrates using screen printing techniques. The method was applicable to square and rectangular cells and can be used to apply dopants of opposite types to the front and back of the substrate. Then simultaneous diffusion of both dopants can be performed with a single furnace pass.

Official Gazette of the U.S. Patent Office

N79 11472\* National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

## SOLAR CELL COLLECTOR AND METHOD FOR PRODUCING SAME Patent

John C Evans Jr. inventor (to NASA). Issued 24 Oct. 1978 5 p. Filed 2: Oct. 1977. Division of US Patent Appl. SN 770869. Filed 22 Feb. 1977. US Patent 4 C82 569.

NASA Case LFW 12552 2 US Patent 4 122 214

US-Patent Appl SN 844346 US Patent Class 4?7 75

US Patent Class 427 84 US Patent Class 427 123

US Palent Class 427 126 US Patent Class 427 261

US Patent Class 427 343 US Patent Class 427 398A US Patent Class 427 399 US Patent Class 29 572

US Patent 4 082 569 US Patent Appl SN 770869) Avail US Patent Office CSCL 10A

A transparent conductive collector layer containing conductive metal channels is formed as a layer on a photovoltaic substrate by coating a photovoltaic substract with a conductive mixed

metal layer. A heat sink having portions protruding from one of its surfaces is attached. These protruding portions define a continuous pattern in combination with recessed regions among them such that they are in contact with the conductive layer of the photovoltaic substrate. Heating the substrate while simultaneously cividizing the portions of the conductive layer exposed to a gaseous oxidizing substance forced into the recessed regions of the heat sink, creates a transparent metal oxide layer on the substrate. A continuous pattern of highly conductive metal channe's is contained in the metal oxide layer.

Official Gazette of the U.S. Patent Office

N79-11477\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## OPTIMUM DRY-COOLING SUB-SYSTEMS FOR A SOLAR AIR CONDITIONER

James L S Chen and David Namkoong Oct 1978 41 prefs

(NASA-TM-79007, E-9788) Avail NTIS HC A03/MF A01 CSCL 10A

Dry-cooling sub-systems for residential solar powered Rankine compression air condifichers were economically optimized and compared with the cost of a well-booling tower. Results in terms of yearly incremental busbar cost due to the use of dry-cooling were presented for Chillidelphia and Miami. With input data corresponding to local weather energy rate and capital costs, condenser surface designs and performance, the computerized children program yields design specifications of the sub-stem where has the lowest annual incremental cost. Author

N79-11478\* National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

## PRELIMINARY SUMMARY OF THE ETF CONCEPTUAL STUDIES

George R. Seikel. Robert W. Bergaw, C. Victor Pearson (Argonne Natl. Lab.). and William R. Owens (Gilbert Assoc. Inc.). 1978. 20 p. refs. Presented at the 4th US USSR Collog on MHD Elec. Power Generation: Washington, D. C. 5-6 Oct. 1978. (Contract EF 77-A-01-2674).

(NA SA TM 78999 E 9783 DOE/NASA/2674 78/1) Avail NTIS HC A02/MF A01 CSCL 10A

Power plant studies have shown the attractiveness of MHD topped steam power plants for baseload utility applications. To realize these advantages a three phase development program was initiated. In the first phase, the engineering data and experience were developed for the design and construction of a pilot plant, the Engineering Test Facility (ETF). Results of the ETF studies are reviewed. These three parallel independent studies were conducted by industrial team - led by the AVCO. Everett Research Laboratory, the Gene al Electric Corporation, and the Westinghouse Corporation. A preliminary analysis and the status of the critical evaluation of these results are presented.

N79 11479\* National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

## SUPPLY OF REACTANTS FOR REDOX BULK ENERGY STORAGE SYSTEMS Final Report

Randall F Gahn Sep 1978 12 p refs

(Contract E(49 28) 1002)

(NASA TM 78995 E 9779 DOE/NASA/1002 78/1) Avail NTIS HC 202/MF A01 CSCL 10A

World resources reserves production and costs of reactant materials iron chromium trianium and bromine for proposed redox cell bulk energy storage systems are reviewed. Supplying required materials for multimegawath hour systems appears to be feasible even at current production levels. Iron and chromium ores are the most abundant and lowest cost of four reactants. Chromium is not a domestic reserve, but redox system installations would represent a small fraction of U.S. imports. Vast quantities of bromine are available but present production is low and therefore cost is high. Titanium is currently available at reasonable cost, with ample reserves available for the next fifty years.

SBS

N79-11480\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## CORRELATIONS OF CATALYTIC COMBUSTOR PERFORM ANCE PARAMETERS

Daniel L. Bulzaii. Oct. 1978 - 15 p. refs. Presented at the 3d Workshop on Catalytic Combust. Asheville. N. C., 2-4 Oct. 1978 sponsored by EPA.

(Contract EC-77-A 31 1040)

(NASA TM 79014 E-9803 DOE/NASA/1040-78/4) Avail NTIS HC A02/MF A01 CSCL 10A

Correlations for combustion efficiency percentage drop and the minimum required adiabatic reaction temperature necessary to meet emissions goals of 136 g CO/kg fuel and 164 g HC/kg fuel are presented. Combustion efficiency was found to be a function of the cell density ceil circumference, reactor lerigth, reference velocity, and adiabatic reaction temperature The perce stage pressure drop at an adiabatic reaction temperature of 1450 K was found to be proportional to the reference velocity to the 1.5 power and to the reactor length. It is inversely proportional to the pressure cell hydraulic diameter and fractional open area. The minimum required adiabatic reaction temperature was found to increase with reference velocity and decrease with cell circumference, cell density and reactor length A catalyst factor was introduced into the correlations to account for differences between catalysts. Combustion efficiency the percentage pressure drop, and the minimum required adiabatic reaction temperature were found to be a function of the catalyst factor. The data was from a 12 cm diameter testing with noble. metal reactors using propane fuel at an iniet temperature of 800 K

N79-11481\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

### THERMAL STORAGE FOR INDUSTRIAL PROCESS AND REJECT HEAT

R A Duscha and W J Masica 1978 14 p. refs. Presented at the 2d Conf. on Waste Heat Management and Util. Miami. Beach 11a. 4.6 Dec. 1978.

(Contract EC-77 A 31 1034)

(NASA TM 78994 E 9777 DCC/NASA/ .034 78/3) Avail NTIS HC A02/MF A01 CSCL 10A

Industrial production uses about 40 percent of the total energy consumed in the United States. The major share of this is derived from fossil fuel. Potential savings of scarce fuel is possible through the use of thermal energy storage (TES) of reject or process heat for subsequent use. Three especially significant industries where high temperature TES appears attractive—paper and pulpiron and steel, and cement are discussed. Potential annual fuel savings, with large scale implementation of near term. TES systems for these three industries is nearly 9,000,000 bit of oil.

S.B.S.

N79-12548\*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

## MICEOPROCESSOR CONTROL OF A WIND TURBINE GENERATOR

Arthur J. Gnecco and Gary T. Whitchead. 1978. 17. p. Presented at the Conf. on Ind. Appl. of Microprocessors, Philadelphia, 20-22. Mar. 1978, sponsored by IEES.

(Contract E(49-26)-1028)

(NASA-TM-79021, E-9818, DOE/NASA/1028-78/20) Avail. NTIS HC A02/MF A01 CSCL 108

A microprocessor based system was used to control the unattended operation of a wind turbine generator. The turbine and its microcomputer system are fully described with special emphasis on the wide variety of tasks performed by the microprocessor for the safe and efficient operation of the turbine. The flexibility cost and reliability of the microprocessor were major factors in its selection.

N79-14628\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

BACK WALL SOLAR CELL Petent

Henry W Brandhorst, Jr., inventor (to NASA) Issued 26 Dec 1978 5 p Filed 24 Apr 1978 Supersedes N78-25556 (16 16, p. 2137) Continuation-in-part of abandoned US Patent Appl. SN-760771, filed 19 Jun. 1977

(NASA-Case-LEW-12236-2; US-Patent-4 131.486; US-Patent-Appl-SN-899123; US-Patent-Class-136-89SJ;

U.S.-Patent-Class-357-30, U.S.-Patent-Appl-SN-760771) Avail U.S. Patent and Trademark Office CSCL 10A

A solar cell is disclosed which comprises a first semiconductor material of one conductivity type with one face having the same conductivity type but more heavily doped to form a field region arranged to receive the radiant energy to be converted to electrical energy, and a layer of a second semiconductor material, preferably highly doped, of opposite conductivity, type on the first semiconductor material adjacent the first semiconductor material at an interface remote from the heavily doped field region. Instead of the opposite conductivity layer, a metallic Schottky diode layer may be used, in which case no additional back contact is needed. A contact much as a gridded contact, previous to the radiant energy may be applied to the heavily doped field region of the more heavily doped, same conductivity material for its contact. Official Gazette of the U.S. Patert and Trademark Office

N79-14538\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

## CATALYST SURFACES FOR THE CHROMOUS/CHROMIC REDOX COUPLE Patent Application

Jose D. Giner (Giner, Inc., Waltham, Mass.) and Kathleen J. Cahill, inventors (to NASA) (Giner, Inc., Waltham, Mass.) Filed 29 Nov. 1978. 13 p. Sponsored by NASA.

(NASA-Case-LEW-13148-1, US-Patent-Appl-SN-964754). Avail. NT:S. HC A02/MF A01. CSCL 104.

An electricity-producing cell of the reduction-oxidation (REDOX) type is presented. The cell comprises a container divided into anode and cathode compartments by an ion permeable membrane. The novelty of the invention appears to lie in the provision of selected catalytic coatings with lead on the anode electrode of a REDOX cell to greatly increase current density.

NASA

N79-15403\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

# COMPARISON OF FUEL CELL AND DIESEL INTEGRATED ENERGY SYSTEMS AND A CONVENTIONAL SYSTEM FOR A 500-UNIT APARTMENT

Stephen N Simons and William L Maag 7lov 1978 26 p refs

(NASA-TM-79037 E 9835) Avail NTIS HC A03/MF A01 CSCL 10B

The electrical and thermal energy utilization efficiencies of a 500 unit apertment complex are analyzed and compared for each of three energy supply systems. Two on site integrated energy systems, one powered by diesel engines and the other by phosphoric-acid fuel cells were compared with a conventional system which uses purchased electricity and on site boilers for heating. All fuels consumed on-site are clean, synthetic fuels (distillate fuel oil or pipeline quality gas) derived from coal Purchased electricity was generated from coal at a central station utility. The relative energy consumption and economics of the three systems are analyzed and compared.

Authoritically application of the systems are analyzed and compared.

N79-15410\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

### BENEFITS OF SOLAR FOSSIL HYBRID GAS TURBINE

Harvey S Bloomfield 1978 18 p refs Proposed for Presentation at the Gas Turbine Conf. and Solar Energy Conf. San Diego. Calif. 12 15 Mar. 1979. sponsored by Am. Soc. of Mech. Engr.

(NASA TM 79083 E-9905) Avail NTIS HC A02/MF A01 CSCL 10A

The potential benefits of solar/fossil hybrid gas turbine power systems were assessed. Both retrofit and new systems were considered from the aspects of cost of electricity fuel conservation operational mode technology requirements, and fuels flexibility. Hybrid retrofit (repowering) of existing combustion (simple Brayton cycle) turbines can provide near-term fuel savings.

arid solar experience, white new and advanced recuperated or combined cycle systems may be an attractive fuel saving and economically competitive vehicle to transition from today's gas and oil-fired powerplants to other more abundant fuels. Author

N79-18411\*# National Agronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PHUTOVOLTAIC POWER SYSTEMS FOR RURAL AREAS OF DEVELOPING COUNTRIES

Louis Rosenblum, William J. Bifano, Garald F. Hein, and Anthony F. Ratajczak 1979 19 p refs Presented at the Intern. Seminar on Solar Energy, Takyo, 5-10 Feb 1979, sponsored by the United Nations and Govt. of Japan

(NASA-TM-79097, E-9921) Avail NTIS HC A02/MF AC1 CSCL 10A

Systems technology, reliability, and present and projected costs of photovoltaic cystems are discussed using data derived from NASA, Lewis Research Center experience with photovoltaic systems deployed with a variety of use . Operating systems in two villages, one in Upper Volta and a other in southwestern Arizona are described. Energy cost in trisons are presented for photovoltaic systems versus alternal anergy sources. Based on present system technology, raliability, and costs, photovoltaics provides a realistic energy option for developing nations.

N79-16355\*# Narronal Aeronautics and Space Administration Lewis Research Center, Cieveland, Ohio.

POWER TRAIN ANALYSIS FOR THE DOE NASA 100-KW WIND TURBINE GENERATOR Final Report

Robert C. Seidel, Harold Gold, and Leon M. Wenzel Oct. 1978 57 p refs Prepared for DOE

(Contract E(49-25) (028)

(NASA-TM-78997, DOE/NASA/1028-78/19, E-9413) Avail NTIS HC A04/MF A01 CSCL 10A

Progress in explaining variations of power experienced in the on-line operation of a 100 kW experimental wind turbinegenerator is reported. Data are presented that show the oscillations tend to be characteristic of a wind-driven synchronous generator because of low torsional damping in the power train. resonances of its large structure, and excitation by unsteady and nonuniform wind flow. The report includes dynamic analysis of the drive-train torsion, the generator, passive driveline damping, and active pitch control as well as correlation with experimental recordings. The analysis assumes one machine on an infinite bus with constant generator-field excitation. Author

N79-16356\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## BASELINE PERFORMANCE OF THE GPU 3 STIRLING

Lanny G Thieme and Roy C. Tew. Jr. Nov 1978 14 p refs Presented at the Highway Vohicle Systems Contractors Coordination Meeting, Dearborn, Michigan, 17-20 Oct. 1978. (Contract EC-77-A-31-1040)

(NASA-TM-79038, E-9838, DOE/NASA/1040-78/5) Avail NTIS HC A02/MF A01 CSCL 10B

A 10 horsepower single-cylinder rhombic-drive Stirling engine was converted to a research configuration to obtain data for validation of Stirling computar simulations. The engine was originally built by General Motors Research Laboratories for the U.S. Army in 1965 as part of a 3 kW engine-generator set. designated the GHU 3 (Ground Power Unit) This report presents test results for a range of heater gas temperatures, mean compression-space pressures, and engine speeds with both helium and hydrogen as the working fluids. Also shown are initial data comparisons with computer simulation predictions.

N79-16367\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### AN OPERATING 200 KW HORIZONTAL AXIS WIND TURBINE

Cha:les L. Hunnicutt (Lockheed Aircraft Service Co., Ontario, Calif.), Bradford Linscott, and Robert A. Wolf 1978 25 p Presented at 23rd Natl. SAMPE Symp. and Exhibition, Anaheim, Calif., 2-4 May 1978

(Contract E(49-26)-1004)

(NASA-TM-79034: E-9833) Avail NTIS HC A02/MF A01 CSCL 10B

The Mod-OA wind turbine blades were rotated for the firs' time on November 30, 1977, establishing the Mod-OA as the first wind-driven generator in 35 years to be continually tied into an electrical power system which services a community. Tower-mounted equipment and plade structural design and fabrication are discussed

N79-17313\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### FORMULATED PLASTIC SEPARATORS FOR SOLUBLE ELECTRODE CELLS Patent

Dean W. Sheibley, inventor (to NASA) Issued 9 Jan. 1979 8 p Filed 10 Mar 1977 Supersedes N77-18560 (15 - 09. p 1194)

INASA-Case-LEW-12358-1; US-Patent-4,133,941;

US-Patent-Appl-SN-776146: US Patent-Class-429-33 US-Patent-Class-429-101) Avail: US Patent and Trademark Office CSCL 10A

The fabrication and milling of membranes comprising a hydrochloric acid-insoluble sheet of a mixture of a rubber and a powdered ion transport material are described. The sheet can he present as 3 coating upon a flexible and porous substrate. These membranes can be used in oxidation-reduction electrical accumulator cells wherein the reduction of one member of a couple is accompanied by the by the oxidation of the other member of the couple on the other side of the cell and this

must be accompanied by a change in chloride ion concentration in both sides Official Gazette of the U.S. Patent and Trademark Office

N79-17333\*# National A ronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

#### A 200-KW WIND TURBINE GENERATOR CONCEPTUAL DESIGN STUDY

Jan 1979 111 p reis (Contract E(49-26)-1028)

(NASA-TM-79032 DOE/NASA/1028-79/1) Avail NTIS HC A06/MF A01 CSCL 10B

A conceptual design study was conducted to define a 200 kW wind turbine power system configuration for remote applications. The goal was to attain an energy cost of 1 to 2 cents per kilowatt-hour at a 14 mph site (mean average wind velocity at an sititude of 30 ft.) The costs of the Clayton, New Mexico. Mod-OA (200-kW) were used to identify the components, subsystems and other factors that were high in cost and thus candidates for cost reduction. Efforts devoted to developing component and subsystem concepts and ideas resulted in a machine concept that is considerably simpler lighter in weight. and lower in cost than the present Mod-OA wind turbines. In this report are described the various innovations that contributed to the lower cost and lighter weight design as viell as the method used to calculate the cost of energy

N79-17334\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohic

EFFECT OF THERMAL BARRIER COATINGS ON THE PERFORMANCE OF STEAM AND WATER COOLED GAS TURBINE STEAM TURBINE COMBINED CYCLE SYSTEM Final Report

Joseph J Nainiger Dec 1978 37 p refs

Contract EF-77 A-01 2593; INA SA TM 79057, E-9807, DOE/NASA/2593-78/4) Avail NTIS HC A03/MF A01 CSCL 10B

An analytical study was made of the performance of air. steam, and water-cooled gas-tu-bine/steam turbine combinedcycle systems with and without thermal-barrier coatings. For steam cooling, thermal barrier coatings permit an increase in the turbine inlet temperature from 1205 C (2200 F), resulting in an efficiency improvement of 1.9 percentage points. The maximum specific power improvement with thermal barriers is 32.4 percent, when the turbine in et temperature is increased from 1425 C (2600 F) to 1675 C (3050 F) and the airfoil temperature is kept the same. For water cooling, the maximum efficiency improvement is 2.2 percentage points at a turbine inlet temperature of 1683 C (3062 F) and the maximum specific power improvement is 36.6 percent by increasing the turbine inlet temperature from 1425 C (2600 F) to 1730 (3150 F) and keeping the airfoil temperatures the same. These improvements are greater than that obtained with combined cycles using air cooling at a turbine inlet temperature of 1205 C (2200 F). The large temperature differences across the thermal barriers at these high temperatures, however, indicate that thermal stresses may present obstacles to the use of coatings at high turbine inlet temperatures. Author

N79-17336\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EVALUATION OF THE ECAS OPEN CYCLE MHD POWER PLANT DESIGN Final Report
George R. Seikel, Peter J. Staiger, and Carlson C. P. Pian Nov.

1978 27 p refs Prepared for DOE (Contract EF-77 A-01-2674)

(NASA-TM-79012, E-9799; DOE/NASA/2674-78/2) Avail:

NTIS HC A03/MF A01 CSCL 10B

The Energy Conversion Alternatives Study (ECAS) MHD/ steam power plant is described. The NASA critical evaluation of the design is summarized. Performance of the MHD plant is compared to that of the other type ECAS plant designs on the basis of efficiency and the 30-year levelized cost of electricity. Techniques to improve the plant design and the potential performance of lower technology plants requiring shorter development time and lower development cost are then discussed.

N79-1/336\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PHOTOVOLTAIC TESTS AND APPLICATIONS PROJECT Final Progress Report, Apr. 1976 - Jun. 1977

Nov 1978 90 p refs

(Contract E(49-26)-1022)

(NASA-TM-79018: E-9811: DOE/NASA/1022-78/42) Avail: NTIS HC A05/MF A01 LSCL 10A

The activities and accomplishments of the Photovoltaic Tests and Applications Project during the period April 1976 through June 1977 are summarized. Results of efforts to identify potential near-term photovoltaic applications and users are discussed. including the outcome of an extensive survey of Federal government agencies. The status of application experiments is presented Various general engineering efforts are reported. including the design and construction of a photovoltaic Systems Test Facility. Efforts to develop a high efficiency 10 kVA self-commutated inverter and controller specifically designed for photovoltaic systems are also discussed. The results of a wide variety of activities in the area of photovoltaic measurements and standards are related Documents generated by the Project during the reporting period are listed in an Appendix.

N79-18444\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

METHOD FOR FABRICATING SCLAR CELLS HAVING INTEGRATED COLLECTOR GRITS Fatent

John C Evans Jr. inventor (to NASA) Issued 23 Jan 1979 6 p. Filed 23 Dec. 1977 Supersedes N78 25558 (16 - 16. p 2138) Division of US Patent Appl SN 803823, filed 6 Jun. 1977 US Patent 4,104 084

NASA Case LEW 12819-2 US Patent 4 135 290 US-Patent Appl SN 863770, US Patent Class-29-572. US Patent Class 29 578 US Patent Class 29 591

US-Patent-Class-148-6 3, US-Patent-4, 104, 084;

US-Patent-Appl-SN-803823) Avail US Patent and Trademark Office CSCL 10A

The photovoltaic devices of the invention are heterojunction or Schottky barrier devices which possess an integral mixed metal oxide coating in which is embedded a metallic network which functions as an efficient collector of electrons set in motion by the photovoltaic process. The metal grid system is formed from the metal elements of the transparent, conductive mixed metal oxide coating which is in contact with the oxide coating which constitutes the barrier of the devices with the semiconductor substrate

Official Gazette of the U.S. Patent and Trademark Office

N79-18455\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ATOMIC HYDROGEN STORAGE METHOD AND AP-**PARATUS Patent Application** 

John A. Woolam, inventor (to NASA) Filed 6 Feb. 1979 10 p

(NASA-Case-LEW-12081-3; US-Patent-Appl-SN-009887) Avail NTIS HC A02/MF A01 CSCL 10B

Atomic hydrogen, for use as a fuel or an explosive is stored in the presence of a strong magnetic field in exfoliated layered compounds such as molybdenum disulfide or an elemental layer material such as graphite. The compound is maintained at liquid helium temperatures and the atomic hydrogen is collected on the surfaces of the layered compound which are exposed during delamination (exfoliation) The strong magnetic field and the low temperature combine to prevent the atoms of hydrogen from NASA combining to form molecules

N79-20494°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

UTILITY OPERATIONAL EXPERIENCE ON THE NASA/DOE MOD-QA 200-kW WIND TURBINE

J. C. Glasgow and W. H. Robbins 1979 30 p refs Presented at the 6th Energy Technol. Conf., Washington, D. C., 26-28 Feb 1979; sponsored by Am. Gas Assoc. - Gas Res Inst., Elec Power Res. Inst., and Thomas Alva Edison Found. (Contract F(49-26)-1004)

(NASA-TM-79084, E9907; DOE/NASA/1004-79/1) Avail: NTIS HC A03/MF A01 CSCL 108

The Mod-OA 200 wind turbine was designed and fabricated as part of the Federal Wind Energy Program. Early wind turbine operation and performance data were obtained while gaining initial experience in the operation of large, horizontal axis wind turbines in typical utility environments. The Mod-OA wind turbine was turned over to the Town of Clayton Light and Water Plant, Clayton, NM, for utility operation and on December 31, 1978, the machine had completed ten months of utility operation. The machine is described and the recent operational experience at Clayton, NMis documented. JMS

N79-20498\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

THERMAL STORAGE TECHNOLOGIES FOR SOLAR INDUSTRIAL PROCESS HEAT APPLICATIONS

Larry H. Gordon 1979 19 p refs (Contract EC-77-A-31-1034)

(NASA-TM-79130: DOE/NASA/1034-79/2: E-9970) Avail NTIS HC A02/MF A01 CSCL 10A

The state-of-the-art of thermal storage subsystems for the intermediate and high temperature (100 C to 600 C) solar industrial process heat generation is presented. Primary emphasis is focused on buffering and diurnal storage as well as total energy transport in addition, advanced thermal storage concepts which appear promising for future solar industrial process heat applications are discussed. JMS

N79-20520\* National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

DECAY OF THE ZINCATE CONCENTRATION GRADIENT AT AN ALKALINE ZINC CATHODE AFTER CHARGING

Harold E. Kautz and Charles E. May 1979 21 p refs To be presented at the Meeting of the Electrochem. Soc., Los Angeles. 14-19 Oct. 1979

(NASA-TM-79106; E-9931) Avail: NTIS HC A02/MF A01 CSCL 10C

The transport of the zincate ion to the alkaline zinc cathode was studied by observing the decay of the zincate concentration gradient at a horizontal zinc cathode after charging. This docay was found to approximate first order kinetics as expected from a proposed boundary layer model. The concentrations were calculated from polarization voltages. The decay half life was shown to be a linear function of the thickness of porous zinc deposit on the cathode indicating a very rapid transport of zincate through porous zinc metal. The rapid transport is attributed to an electrochemical mechanism. From the linear dependence of the half life on the thickness the boundary layer thickness was found to be about 0.010 cm when the cathode was at the bottom of the cell. No significant dependence of the boundary layer thickness on the viscosity of electrolyte was observed. The data also indicated a relatively sharp transition between the diffusion and convection transport regions. When the cathode was at the top of the cell, the boundary layer thickness was found to be roughly 0.080 cm. The diffusion of zincate ion through asbestos submerged in alkaline electrolyte was shown to be comparable with that predicted from the bulk diffusion coefficient of the zincate ion in alkali JMS

N79-21549\*# National Aeronautics and Space Administration. Lawis Research Center, Cleveland, Ohio.

EVALUATION OF MOSTAS COMPUTER CODE FOR PREDICTING DYNAMIC LOADS IN TWO BLADED WIND TURBINES

K. R. V. Kaza (Toledo Univ.), D. C. Janetzke, and T. L. Sullivan 1979 21 p refs Presented at AIAA/ASCE/AHS 20th Structures, Structural Dynamics and Mater Conf., St. Louis, Mo., 4-6 Apr. 1979.

(Contract E(49-26)-1028)

(NASA-TM-79101: DOE/NASA/1028-72/2: E-9925) Avail. NTIS HC A02/MF A01 CSCL 10B

Calculated dynamic blade loads were compared with measured loads over a range of yaw stiffnesses of the DOE/NASA Mod-O wind turbine to evaluate the performance of two versions of the MOSTAS computer code. The first version uses a time-averaged coefficient approximation in conjunction with a multi-blade coordinate transformation for two bladed rotors to solve the equations of motion by standard eigenanalysis. The second version accounts for periodic coefficients while solving the equations by a time history integration. A hypothetical three-degree of freedom dynamic model was investigated. The exact equations of motion of this model were solved using the Floquet-Lipunov method. The equations with time-averaged coefficients were solved by standard eigenanalysis.

N79-21550° Mational Aeronautics and Space Administration. Lawis Research Center, Cleveland, Ohio.

#### THE ROLE OF THERMAL ENERGY STORAGE IN INDUSTRI-AL ENERGY CONSERVATION

Rudolph A. Duscha and William J. Masica 1979 13 p. refs. Presented at a Conf. on Ind. Energy Conserv. Technol and Exhibition, Houston. Tex., 22-25 Apr. 1979; sponsored by DOE and the Texas Ind. Comm.

(Contract EC-77-A-31-1034)

(NA SA-TM-79122: DOE/NASA/1034-79/1: E-9957) Avail. NTIS HC A02/MF A01 CSCL 10C

Thermal Energy Storage for Industrial Applications is a major thrust of the Department of Energy's Thermal Energy Storage Program. Utilizing Thermal Energy Storage (TES) with process or reject heat recovery systems is shown to be extremely beneficial for several applications. Recent system studies resulting from contracts awarded by the Department of Energy (DOE) identified four especially significant industries where TES appears attractive—food processing, paper and pulp, iron and steel, and cement

Potential annual fuel savings with large scale implementation of near term TES systems for these industries is over 9,000,000 bbl of oil. This savings is due to recuperation and storage in the food processing industry, direct fuel substitution in the paper and pulp industry and reduction in electric utility peak fuel use through inplant production of electricity from utilization of reject heat in the steel and cement industries.

Author

N79-21676°# National Aeronautics and Spaca Administration. Lewis Research Center, Cleveland, Ohio.

LEWIS RESEARCH CENTER PROGRAM

D. G. Soltis In NASA. Goddard Space Flight Center 1977 Goddard Space Flight Center Battery Workshop 1977 p. 133-136 (For primary document see N79-21565 12-44) Avail: NTIS HC A25/MF A01 CSCL 10C

As part of the NASA lightweight battery program, the Lewis Research Center has a number of programs that are being reviewed. A brief and general discussion of these programs is presented.

GY.

N79-22623\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PRELIMINARY COMPARISON OF THEORY AND EXPERIMENT FOR A CONICAL, PRESSURIZED-FLUIDIZED-BED COAL COMBUSTOR

R. W. Patch Mar. 1979 E6 p refs

(NASA-TM-79137, E-9985) Avail NTIS HC A04/MF A01 CSCL 10A

A published model was used for a comparison of theory with an actual combustor burning caking bituminous coal and using limestone to reduce sulfur dioxide emission. Theoretical bed pressure drop was in good agreement with experiment. The burnable carbon elutriated was not in agreement with experiment, at least partly because the exhaust port was apparently below the transport cisengaging height. The observed nitrogen oxides emission rate was about half the theoretical value. There was order-or-magnitude agreement of sulfur dioxide emission rates.

N79-22624\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## ANALYSIS OF A FUEL CELL ON-SITE INTEGRATED ENERGY SYSTEM FOR A RESIDENTIAL COMPLEX

Stephen N Simons and William L. Maag (Solar Energy Products Co. Avon Lake, Ohio). 1979–11 p. refs. Proposed for presentation at the Terrest. Energy Systems Conf., Orlando, Fla., 4-6 Jun. 1979, sponsored by AIAA.

(NASA-TM-79161: E 018) Avail NTIS HC A02/MF A01 CSCL 108

Declining supplies of domestic oil and gas and the increased cost of energy resulted in a renewed emphasis in utilizing available resources in the most efficient manner possible. This, in turn, brought about a reassessment of a number of methods for converting fossil fuels to end uses at the highest practical efficiency. One of these is the on-site integrated energy system (OS/IES). This system provides electric power from an on-site power plant and recovers heat from the power plant that would normally be rejected to the environment. An OS/IES is potentially useful in any application that requires both electricity and heat Several OS/IES are analyzed for a residential complex. The paper is divided into two sections, the first compares three energy supply systems the second compares various designs for fuel cell OS/IES.

N79-22626\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

EFFECT OF STEAM ADDITION ON CYCLE PERFORMANCE OF SIMPLE AND RECUPERATED GAS TURBINES

Robert J. Boyle Apr 1979 52 p refs

(NASA-TP-1440, E-9795) Avail NTIS HC / 1/MF A01 CSCL 10R

Results are presented for the cycle efficiency and specific power of simple and recuperated gas turbine cycles in which

steam is generated and used to increase turbine flow. Calculations showed significant improvements in cycle efficiency and specific power by adding steam. The calculations were made using component efficiencies and loss assumptions typical of stationary powerplants. These results are presented for a range of operating temperatures and pressures. Relative heat exchanger size and the water use rate are also examined.

N79-24442\* Mational Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

REDOX FLOW CELL ENERGY STORAGE SYSTEMS

Lawrence H. Thaller 1979 11 p refs

(Contract E(49-28)-1002)

(NASA-TM-79143: DOE/NASA/1002-79/3: E-9996, Avail: NTIS HC A02/MF A01 CSCL 10A

NASA-Redox systems are electrochemical storage devices that use two fully soluble Redox couples, anode and cathode fluids, as active electrode materials separated by a highly selective ion exchange membrane. The reactants are contained in large storage tanks and pumped through a stack of Redox flow cells where the electrochemical reactions (reduction and oxidation) take place at porous carbon felt electrodes. A string or stack of these power producing cells is connected in series in a bipolar manner. Redox energy storage systems promise to be inexpensive and possess many features that provide for flexible design, long life, high reliability and minimal operation and maintenance costs. These features include independent sizing of power and storage capacity requirements and inclusion within the cell stack (f. a. cell that monitors the state of charge of the system as a whole, and a rebalance cell which permits continuous correction to be made for minor side reactions that would tend to result in the anode fluid and cathode fluids becoming electrochemically out of balance. These system features are described and discussed

N79-24443\*# National Aeronautics and Space Administration. Lewis Research Center. Cleveland Ohio.

#### DESCRIPTION OF PHOTOVOLTAIC VILLAGE POWER SYSTEMS IN THE UNITED STATES AND AFRICA

A. F. Ratajczak and W. J. Bifano. 1979. 13 p. refs. Presented at the Photovoitaic Solar Energy Conf., Berlin, 23-26 Apr. 1979 (Contract DE-A101-79ET20485)

(NASA-TM-79149: DOE/NASA/20435-79/1: E-005) Avail: NTIS HC A02/MF A01 CSCL 10B

Photovoltaic power systems in remote villages in the United States and Africa are described. These projects were undertaken to demonstrate that existing photovoltaic system technology is capable of providing electrical power for basic domestic services for the millions of small, remote communities in both developed and developing countries. One system is located in the Papago Indian Village of Schuchuli in southwest Arizona (U.S.) and became operational 16 December 1978. The other system is located in Tangaye, a rural village in Upper Volta, Africa It became operational 1 March 1979. The Schuchuli system has a 3.5 kW (peak) solar array which provides electric power for village water pumping a refrigerator for each family, lights in the village buildings, and a community washing machine and sewing machine. The 18 kW (peak) Tangaye system provides power for community water pumping, flour milling and lights in the milling building. These are both stand-alone systems (i.e., no back-up power source) which are being operated and maintained by local personnel Both systems are instrumented Systems operations are being monitored by NASA to measure design adequacy and to refine designs for future systems J M S

N79-24444\* | National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### BENEFITS OF ADVANCED TECHNOLOGY IN INDUSTRIAL COGENERATION

G. J. Barna and R. K. Burns. 1979. 29 p. Presented at EPRI Workshop on Cogeneration, San Antonio, Tex., 1-4 Apr. 1979 (Contract EC 77-A-31-1062)

(NASA-TM 7º160 DOE/NASA/1062-79/1 E 016) Avail NTIS HC A 3/MF A01 CSCL 10B

This broau study is aimed at identifying the most attractive

advanced energy conversion systems for industrial cogeneration for the 1985 to 2000 time period and assessing the advantages of advanced technology systems compared to using today's commercially available technology. Energy conversion systems being studied include those using steam turbines, open cycle gas turbines, combined cycles, diese! engines. Stirling engines. closed cycle gas turbines, phosphoric acid and molten carbonate fuel cells and thermionics. Specific cases using today's commercially available technology are being included to serve as a baseline for assessing the advantages of advanced technology.

N79-24445\* # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### REDOX FLOW CELL DEVELOPMENT AND DEMONSTRA-TION PROJECT, CALENDAR YEAR 1977

Jan. 1979 53 p refs

(Contract E(49-28)-1002)

(NASA-TM-79067; DOE/NASA/1002-78/2; E-9883) Avail: NTIS HC A04/MF A01 CSCL 10A

Research and development on the redox flow cell conducted from January 1, 1977, to December 31, 1977, are described in this report The major focus of the effort during 1977 was the key technology issues that directly influence the fundamental feasibility of the overall redox concept. These issues were the development of a suitable ion exchange membrane for the system. the screening and study of candidate redox couples to achieve optimum cell parto, and and and the carrying out of systems analysis and modeling to develop system performance goals and cost estimates

N79-24446\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

#### PERFORMANCE OPTIMIZATION OF AN MHD CENERATOR WITH PHYSICAL CONSTRAINTS

C. C. P. Pian, G. R. Seikel, and J. Marlin Smith 1979 12 p. refs Proposed for presentation at 14th Intersoc. Energy Conversion Eng. Conf., Boston, 5-10 Aug. 1979 (Contract EF-77-A-01-2674)

(NASA-TM-79172: DOE/NASA/2674-79/5; E-036) Avail: NTIS HC A02/MF A01 CSCL 10B

A method to optimize the Faraday MHD generator performance under a prescribed set of electrical and magnet constraints is described. The results of generator performance calculations using this technique are presented for a very large MHD/steam plant. The differences between the maximum power and maximum net power generators are described. The sensitivity of the generator performance to the various operational parameters are presented Author

N79-25481\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### IN SITU SELF CROSS-LINKING OF POLYVINYL ALCOHOL BATTERY SEPARATORS Petent

Warren H Philipp, Li-Chen Hsu, and Dean W Sheibley inventors (to NASA) Issued 15 May 1979 5 p Filed 19 Apr. 1978 Supersedes N78-22157 (16 - 13, p 1674)

NASA-Case-LEW-12972-1; US-Patent-4,154,912

US-Patent-Appl-SN-897829 US-Patent-Class-526-7

US-Patent-Class-429-253, US-Patent-Class-526-9) Avail US

Patent and Trademark Office CSCL 10C

A battery separator was produced from a polyvinyl alcohol sheet structure which was subjected to an in situ, self crosslinking process by selective oxidation of the 1,2 diol units present in the polyvinyl alcohol sheet structure. The 1,2 diol units were cleaved to form aldehyde end groups which subsequently crosslink through acetalization of the 1.3 diol units of the polyvinyl alcohol. Selective oxidation was achieved using a solution of a suitable oxidizing agent such as periodic acid or lead tetraacetate

Official Gazette of the U.S. Patent and Trademark Office

N79-25492\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

#### DOE PHOTOVOLTAIC TESTS AND APPLICATIONS PRO-JECT

Ron Cull and Tony Ratajczak In OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop and Appl. Program Rev. 1978 p 1-166 - 1-179 (For primary document see N79-25485 16-44)

Avail NTIS HC A15/MF A01 CSCL 10A

The installation date, system and location, and solar arrays are tabulated. S.E.S.

N79-25498\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GAS-TURBINE CRITICAL RESEARCH AND ADVANCED TECHNOLOGY SUPPORT PROJECT Annual Report, FY 1978

John S. Clark, Carl E. Lowell, Richard W. Niedzwiecki, and Joseph J. Nainiger. Jun. 1979. 46 p. refs.

(Contract EF-77-A-01-2593)

(NASA-TM-79139, DOE/NASA/2593-79/6; E-9986) Avail: NTIS HC A03/MF A01 CSCL 10B

The technical progress made during the first 15 months of a planned 40-month project to provide a critical-technology data base for utility gas-turbine systems capable of burning coal-derived fuels is summarized. Tasks were included in the following areas: (1) combustion, to study the combustion of coal-derived fuels and conversion of fuel-bound nitrogen to NOx. (2) materials, to understand and prevent hot corrosion: and (3) system studies, to integrate and guide the other technologies. Significant progress was made.

N79-25499\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

## MHD PERFORMANCE CALCULATIONS WITH OXYGEN ENRICHMENT

C. C. P. Pian, P. J. Staiger, and G. R. Seikel. 1979. 32 p. refs. Presented at 18th Symp. on Engineering Aspects of Magnetohydrodynamics, Butte. Montana, 18-20 Jun. 1979.

(Contract EF-77-A-01-2674)

(NASA-TM-79140: DOE/NASA/2674-79/4, E-9987) Avail N/IS HC A03/MF A01 CSCL 10A

The impact of oxygen erinchment of the combustion air on the generator and overall plant performance was studied for the ECAS-scale MHD/steam plants. A channel optimization technique is described and the results of generator performance calculations using this technique are presented. Performance maps were generated to assess the impact of various generator parameters. Directly and separately preheated plant performance with varying O2 enrichment was calculated. The optimal level of enrichment was a function of plant type and preheat temperature. The sensitivity of overall plant performance to critical channel assumptions and oxygen plant performance characteristics was also examined.

Author

N79-25500°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

## COMMERCIAL PHOSPHORIC ACID FUEL CELL SYSTEM TECHNOLOGY DEVELOPMENT

Paul R Prokopius, Marvin Warshay, Stephen N Simons, and Robert B King 1979 9 p refs Proposed for presentation at the 14th Intersociety Energy Conversion Engr. Conf., Boston, Mass. 5-10 Aug. 1979

(Contract DE-AI-03-79ET11272)

(NASA-TM-79169, DOE/NASA/11272-79/1, E-034) Avail NTIS HC A02/MF A01 CSCL 10C

Reducing cost and increasing reliability were the technology drivers in both the electric utility and on-site integrated energy system applications. The longstanding barrier to the attainment of these goals was materials. Differences in approaches and their technological leatures, including electrodes, matrices, intercell cooling, bipolar/separator plates, electrolyte management, fuel selectron, and system design philosophy were discussed. Author

N79-26501\* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

## SOCIAL AND ECONOMIC IMPACT OF SOLAR ELECTRICITY AT SCHUCHULI VILLAGE

William J. Bifano, Anthony F. Ratajczak, Donald M. Behr (Arizona State Univ., Tempe), and Billy G. Garrett (Arizona State Univ., Tempe) 1979 18 p refs Presented at the Seminar on Solar Technol. in Rural Settings: Assessments of Field Experiences, Atlanta, Ga., 1-2 Jun. 1979; sponsored by United Nations Univ.

(Contract DE-AI-01-79ET20485)

(NASA-TM-79194; DOE/NASA/20485-79/3; E-071) Avail NTIS Hu A02/MF A01 CSCL 10A

Schuchuli, a small remote village on the Papago Indian Reservation in southwest Arizona, is 27 kilometers (17 miles) from the nearest available utility power. Its lack of conventional power is due to the prohibitive cost of supplying a small electrical load with a long-distance distribution line. Furthermore, alternate energy sources are expensive and place a burden on the resources of the villagers. On December 16, 1978, as part of a federally funded project, a solar cell power system was put into operation at Schuchuli. The system powers the village water pump, lighting for homes and other village buildings, family refrigerators and a communal washing machine and sewing machine.

N7:0-26474\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### ELECTROCHEMICAL CELL FOR REBALANCING REDOX FLOW SYSTEM Patent

Lawrence H Thaller, inventor (to NASA) Issued 26 Jun. 1979 5 p Filed 9 Jun. 1978 Supersedes N78-25554 (16 - 16 p 2137)

(NASA-Case-LEW-13150-1; US-Patent-4.159,366;

US-Patent-Appl-SN-914260; US-Patent-Class-429-15;

US-Patent-Class-429-101) Avail: US Patent and Trademark Office CSCL 10C

An electrically rechargeable REDOX cell or battery system including one of more rebalancing cells is described. Each rebalancing cell is divided into two chambers by an ion permeable membrane. The first chamber is fed with gaseous hydrogen and a cathode fluid which is circulated through the cathode chamber of the REDOX cell is also nassed through the second chamber of the rebalancing cell. Electrochemical reactions take place on the surface of insert electrodes in the first and second chambers to rebalance the electrochemical capacity of the anode and cathode fluids of the REDOX system.

Official Gazette of the U.S. Patent and Trademark Office

N79-26476\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## HANDBOOK OF DATA ON SELECTED ENGINE COMPONENTS FOR SOLAR THERMAL APPLICATIONS

Jun. 1979 240 p refs Prepared for DOE

(Contract EX-76-A-29-1060)

(NA SA-TM-79027, E-9822, DOE/NASA/1060-78, 1) Avail NTIS HC A11/MF A01 CSCL 10B

A data base on developed and commercially available power conversion system components for Rankine and Brayton cycle engines, which have potential application to solar thermal power-generating systems is presented. The status of the Stirling engine is discussed. For individual titles, see N79-26477 through N79-26484.

N79-26477\* National Aeronautics and Spach Administration. Lewis Research Center, Cleveland, Ohio

#### SOLAR THERMAL POWER-CONVERSION SYSTEM

Harvey S Bloomfield In its Handbook of Data on Selected Eng Components for Solar Thermal Appl Jun 1979 p 3-12 (For primary document see N79-26476 17-44)
Avail NTIS HC A11/MF A01 CSCL 10B

The structure, applications, and operating concepts of solar thermal power conversion system are described. S.E.S.

N79-26478\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RANKINE-CYCLE COMPONENT CHARACTERISTICS

Thaddeus S. Mroz and M. Murray Bailey In Its Handbook of Data on Selected Eng. Components for Solar Thermal Appl. Jun. 1979 p 13-83 (For primary document see N79-26476 17-44) Avail: NTIS HC A11/MF A01 CSCL 10B

The performance and cost data for the major components of steam and organic Rankine cycle power conversion systems are presented. Rankine cycle components discussed include: (1) steam and organic turbines; (2) reciprocating engines; (3) surface condensers; and (4) boiler feed and condensate pumps. Component designs, component development status, operating characteristics, availability, cost, and component experience factors are described.

N79-26479°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

BRAYTON-CYCLE COMPONENT CHARACTERISTICS

Thaddeus S. Mroz. Jack A. Heller, and Harvey S. Bloomfield In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl. Jun. 1979 p 85-126 (For primary document see N79-26476 17-44)

Avail: NTIS HC A11/MF A01 CSCL 10B

The gas turbine engine which operates on the Brayton cycle principle is described. The two basic types of Brayton gas turbine engine were developed and are presented in use; the closed cycle engine and open cycle engine.

S.E.S.

N79-26480°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STIRLING ENGINE CHARACTERISTICS

Harry M. Cameron In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl. Jun. 1979 p. 127-157 (For primary document see N79-26476 17-44). Avail: NTIS HC A11/MF A01 CSCL 109

The Stirling engine is described for the following factors (1) excellent fuel economy. (2) low exhaust emissions: (3) multifuel capability: (4) flat torque curve, and (5) low noise level. The Stirling cycle, free piston engines, and the seals and hydrogen containment are discussed.

N79-26481\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SPEED REDUCERS-INCREASERS

Thaddeus S. Mroz. In its Handbook of Data on Selected Eng Components for Solar Thermal Appl. Jun. 1979. p. 159-173 (For primary document see N79-26476 17-44). Avail. NTIS. HC A11/MF A01. CSCL. 108

Prime movers such as steam-organic engines, gas turbines, Stirling engines, and piston engines were designed for peak efficiency at specific operating parameters. Gear systems are used to reduce or increase the output speed of the prime mover to the speed requirement of the driven machine, at the operational load. The configurations of gear systems discussed include. (1) Horizontal parallel-shaft offset, (2) Horizontal parallel-shaft in line, (3) Horizontal right angle, (4) Vertical right angle, and (5) Epicyclic.

N79-26482\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## COMMERCIAL SYNCHRONOUS ALTERNATING-CURRENT GENERATORS

James H. Dunn. In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl. Jun. 1979. p. 175-186 (For primary document see N79-26476 17-44). Avail: NTIS. HC A11/MF A01. CSCL 108

Different types of generator and generator system are discussed. Variable speed and constant frequency systems are described. The flux switch alternator in alternating current generators used for induction hardening was examined for industrial utilization.

N79-26483\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

POWER-CONVERSION SYSTEM COMPONENT SUMMA-

Thaddeus S. Mroz, M. Murray Bailey, Jack A. Haller, Harvey S. Bloomfield, Robert J. Stochl, and Robert E. Hyland *In its* Handbook of Data on Selected Eng. Components for Solar Thermal Appl. Jun. 1979 p 187-190 (For primary document see N79-26476 17-44)

Avail: NTIS HC A11/MF A01 CSCL 10B

Commercial components applicable to Rankine cycle, Brayton cycle, and Stirling cycle solar thermal power generating systems were surveyed. The solar thermal power generating systems and their components are described. Data on these components are presented and include development status, availability, cost operating constraints, operating characteristics, and experience factors.

N79-26484\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
CANDIDATE POWER-CONVERSION SYSTEM CYCLES.

APPENDIX A

Robert J. Stochl in its Handbook of Data on Selected Eng.

Components for Solar Thermal Appl. Jun. 1979 p 191-209

(For primary document see N79-26476 17-44)

Avail: NTIS HC A11/MF A01 CSCL 10B

The Rankine cycle, Brayton cycle, and Stirling cycle are described for solar thermal applications. The basic cycle configuration, its operation, and the basic relations for calculating cycle efficiencies and work outputs are presented. The system modifications used to increase performance over that of the basic cycle are discussed.

N79-26502\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE USE OF WIND DATA WITH AN OPERATIONAL WIND TURBINE IN A RESEARCH AND DEVELOPMENT ENVIRON-MENT

Harold E Neustadter 1979 13 p refs Presented at the Am. Meteorological Soc., Portland, Oreg., 19-21 Jun. 1979 (Contract E(49-26)-1004)

(NASA-TM-73832. DOE/NASA/1004-79/16. E-9419) Avail NTIS HC A02/MF A01 CSCL 10A

The status of the use of wind information is presented in four areas, namely operational control, design verification, power performance analysis, and lifetime estimation. Attention is given to some of the identified wind information needs and the steps taken to meet these needs.

M.M.M.

N79-26503\*# National Aeronautics and Space Administration. Lowis Research Center, Cleveland, Ohio.

A METHOD FOR CORRELATING PERFORMANCE DATA OF A TERRESTRIAL SOLAR CELL ARRAY

Frederick F Simon May 1979 45 p refs Prepared for DOE (NASA-TM-79163, DOE/NASA/20485-79/2, E-023) Avail NTIS HC A03/MF A01 CSCL 10A

An analytical method was proposed for characterizing array power output, in the region of maximum power, as a function of environmental variables. The correlation provided a way of evaluating the output of an array under environmental conditions that differ from those encountered during testing. Power data obtained at one location was used to predict array performance at other locations.

N79-26504\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

LARGE HORIZONTAL AXIS WIND TURBINE DEVELOP-MENT

William H. Robbins and Ronald L. Thomas. 1979. 16 p. refs. Presented at the Wild Energy Innovative Systems. Conf., Colo. Springs, Colo., 23-25. May 1979, sponsored by Solar Energy. Res. Inst.

(Contract E(49-26)-1059)

(NASA-TM-79174; DOE/NASA/1059-79/2; E-039) Avail NTIS HC A02/MF A01 CSCL 10A

An overview of the NASA activities concerning ongoing wind systems oriented toward utility application is presented. Firstgeneration-technology large wind turbines were designed and are in operation at selected utility sites. In order to make a significant energy impact, costs of 2 to 3 cents per kilowatt hour must be achieved. The federal program continues to fund the development by industry of wind turbines which can meet the cost goals of 2 to 3 cents per kilowatt hour. Lower costs are achieved through the incorporation of new technology and innovative system design to reduce weight and increase energy capture

N79-26506\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RECENT ADVANCES IN REDOX FLOW CELL STORAGE SYSTEMS

Lawrence H. Thaller 1979 10 p refs Presented at the 14th Intersoc Energy Conversion Eng. Conf., Boston, 5-10 Aug. 1979 Prepared for DOE

(Contract EC-77-A-31-1002)

(NASA-TM-79186, DOE/NASA/1002-79/4; E-053) Avail: NTIS HC A02/MF AU1 CSCL 10C

Several features which were conceived and incorporated into complete redox systems that greatly enhanced its ability to be kept in proper charge balance, to be capable of internal voltage regulation, and in general be treated as a true multicell electrochemical system rather than an assembly of single cells that were wired together, were discussed. The technology status as it relates to the two application areas of solar photovoltais/wind and distributed energy storage for electric utility applications was addressed. The cost and life advantages of redox systems were also covered

N79-27663\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ENERGY-STATE FORMULATION OF LUMPED VOLUME DYNAMIC EQUATIONS WITH APPLICATION TO A SIMPLIFIED FREE PISTON STIRLING ENGINE

Carl J. Daniele and Carl F. Lorenzo 1979 30 p refs Presented at the Soc for Computer Simulation, Pittsburgh, 21-22 May 1979

(NASA-TM-79197, E-075) Avail NTIS HC A03/MF A01 CSCL 10B

Lumped volume dynamic equations are derived using an energy state formulation. This technique requires that kinetic and potential energy state functions be written for the physical system being investigated. To account for losses in the system. a Rayleigh dissipation function is formed. Using these functions. a Lagrangian is formed and using Lagrange's equation, the equations of motion for the system are derived. The results of the application of this technique to a lumped volume are used to derive a model for the free piston Stirling engine. The model was simplified and programmed on an analog computer. Results are given comparing the model response with experimental data

N79-27664\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

REDUCTION OF PARTICULATE CARRYOVER FROM A PRESSURIZED FLUIDIZED BED

R. W Patch 1979 22 p refs Presented at 2d Symp. on the Transfer and Utilization of Particulate Control Technol., Denver. Colo., 23-27 Jul 1979

(NASA-TM-79216, E-106) Avail NTIS HC A02/MF A01 CSCL

A bench scale fluidized bed combustor was constructed with a conical shape so that the enlarged upper part of the combustor would also serve as a granular bed filter. The combustor was fed coal and limestone. Ninety-nine tests of about four hours each were conducted over a range of conditions. Coal-to-air ratio varied from 0.033 to 0.098 (all lean) Limestone-to-coal ratio varied from 0.06 to 0.36. Bed depth varied from 3.66 to 8.07 feet. Temperature varied from 1447 to 1905 F. Pressure varied from 40 to 82 psia. Heat transfer area had the range zero to 2.72 ft squared. Two cone angles were used. The average particulate carry over of 2.5 grains/SCF was appreciably less than cylindrical fluidized bed combustors. The carry over was correlated by multiple regression analysis to yield the dependence on bed depth and hence the collection efficiency, which was 20%. A comparison with a model indicated that the exhaust port may be below the transport disengaging height for most of the tests, indicating that further reduction in carry over and increase in collection efficiency could be affected by increasing the freeboard and height of the exhaust port above the bed.

Author

N79-27665°# National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.
ENERGY AND COST SAVING RESULTS FOR ADYANCED
TECHNOLOGY SYSTEMS FROM THE COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS)

G. D. Sagerman, G. J. Barna, and R. K. Burns 1979 22 p Presented at AIAA Terrestrial Energy System Conf., Orlando, Fla., 4-6 Jun. 1979

(Contract EC-77-A-31-1062)

(NASA-TM-79213: DOE/NASA/1062-79/2: AIAA-78-1000) Avail NTIS HC A02/MF A01 CSCL 10A

An overview of the organization and methodology of the Cogeneration Technology Alternatives Study is presented. The objectives of the study were to identify the most attractive advanced energy conversion systems for industrial cogeneration applications in the future and to assess the advantages of advanced technology systems compared to those systems commercially available today. Advanced systems studied include steam turbines, open and closed cycle gas turbines, combined cycles, diesel engines. Stirling engines, phospiloric acid and molten carbonate fuel cells and thermionics. Steam turbines, open cycle gas turbines, combined cycles, and diesel engines were also analyzed in versions typical of today's commercially available technology to provide a base against which to measure the advanced systems. Cogeneration applications in the major energy consuming manufacturing industries were considered. Results of the study in terms of plant level energy savings. annual energy cost savings and economic attractiveness are presented for the various energy conversion systems considered.

N79-28672\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

LIGHTWEIGHT POROUS PLASTIC PLAQUE

Margaret Reid In NASA. Goddard Space Flight Center 11th Ann. Battery Workshop 1973 p 31-42 (For primary document see N79-28669 19-44)

Avail NTIS HC A23/MF A01 CSCL 10C

The porosity and platability of various materials were investigated to determine a suitable substrate for nickel-plated electrodes Immersion, ultrasonics, and flow-through plating techniques were tried using nonproprietary formulations, and proprietary phosphide and boride baths. Modifications to the selected material include variations in formulation and treatment, carbon loading to increase conductivity, and the incorporation of a grid Problems to be solved relate to determining conductivities and porosities as a function of amount of nickel plated on the plastics, loading, charge and discharge curves or electrodes at different current densities cell performance, and long-term degradation of electrodes

N79-28725\* National Aeronautics and Space Administration. Lewis Research Center Cleveland, Ohio

SAFETY CONSIDERATIONS IN THE DESIGN AND OPERA-TION OF LARGE WIND TURBINES Final Report

Dwight H Reilly Jun. 1979 38 p refs Sponsored in part by

(Contract DE-AIO1-79ET20305)

(NA SA-TM-79193; E-067, DOE/NASA/20305-79/3) Avail. NTIS HC A03/MF A01 CSCL 10B

The engineering and safety techniques used to assure the reliable and safe operation of large wind turoine generators utilizing the Mod 2 Wind Turbine System Program as an example is described. The techniques involve a careful definition of the wind turbine's natural and operating environments, use of proven structural design criteria and analysis techniques, an evaluation of potential failure modes and hazards, and use of a fail safe and redundant component engineering philosophy. The role of an effective quality assurance program, tailored to specific hardware criticality, and the checkout and validation program developed to assure system integrity are described.

N79-28726\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio. STIRLING ENGINES FOR AUTOMOBILES

Donald G Beremand 1979 15 p refs Proposed for presentation at Intern. Conf. on Energy Use Management, Los Angeles, Calif., 22-26 Oct. 1979 Sponsored in part by DOE (Contract EC-77-A-31-1040)

(NASA-TM-79222: E-116) Avail: NTIS HC A02/MF A01 CSCL 10B

The results of recent and ongoing automobile Stirling engine development efforts are reviewed and technology status and requirements are identified. Key technology needs include those for low cost, high temperature (1300 - 1500 F) metal alloys for heater heads, and reliable long-life, low-leakage shaft seals. Various fuel economy projections for Stirling powered automobiles are reviewed and assessed Author

N79-28727°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN, FABRICATION, AND INITIAL TEST OF A FIXTURE FOR REDUCING THE NATURAL FREQUENCY OF THE MOD-O WIND TURBINE TOWER

J. R. Winemiller, T. L. Sullivan, R. L. Sizemore, and S. T. Yee Jul. 1979 21 p Prepared for DOE

(Contract EX-76-I-01-1028)

(NASA-TM-79200, C-081, DOE/NASA/1028-79/24) Avail NTIS HC A02/MF A01 CSCL 10B

It was desired to observe the behavior of a two bladed wind turbine where the tower first bending natural frequency is less than twice the rotor speed. The system then passes through resonance when accelerating to operating speed. The frequency of the original Mod-O tower was reduced by placing it on a spring fixture. The fixture is adjustable to provide a range of tower bending frequencies. Fixture design details are given and behavior during initial operation is described Author

N79-28728\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EFFECT OF POSITIVE PULSE CHARGE WAVEFORMS ON CYCLE LIFE OF NICKEL-ZINC CELLS Final Report

John J Smithrick Jul 1979 14 p refs Sponsored in part by DOE

Contract EC-77-A-31-1044)

(NASA-TM-79215, E-100, DOE/NASA/1044-79/3) Avail NTIS HC A02/MF A01 CSCL 10C

Five amp-hour nickel-zinc cells were life cycled to evaluate four different charge methods. Three of the four waveforms investigated were 120 Hz full wave rect fied sinusoidal (FWRS). 120 Hz silicon controlled rectified (SCR), and 1 kHz square wave (SW). The fourth, a constant current method, was used as a baseline of comparison. Three sealed Ni-Zn cells connected in series were cycled. Each series string was charged at an average c/20 rate, and discharged at a c/25 rate to a 75%

N79-29599\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

DYNAMIC ANALYSIS OF A PHOTOVOLTAIC POWER SYSTEM WITH BATTERY STORAGE CAPABILITY Final Report

Watter C. Merrill, Ronald J. Blaha, and Roy L. Pickrell. Jul. 1979 47 p ref (DE-AI01-79ET20485)

(NASA-TM-79209: E-094: DOE/NASA/20485-79/4) Avail: NTIS HC A03/MF A01 CSCL 10C

A photovolataic power system with a battery storage capability is analyzed. A dual battery current control concept is proposed. which enables the battery to either supply or accept power depending upon system environment and load conditions. A simulation of the power system, including the battery current control, is developed and evaluated. The evaulation demonstrate the visbility of the battery control concept of switch the battery from a charge to discharge mode and back as required by load and environmental conditions. An acceptable system operation is demonstrated over the entire insolation range. Additionally, system sensitivity, bandwidth, and damping characteristics of the battery control are shown to be acceptable for a projected hardware implementation. Author

N79-29600°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE ALKALINE ZINC ELECTRODE AS A MIXED POTENTIAL SYSTEM

William L. Fielder Jul. 1979 22 p refs (NASA-TM-79235; E-141) Avail NTIS HC A02/MF A01 CSCL 10C

Cathodic and anodic processes for the alkaline zinc electrode in 0.01 molar zincate electrolyte (9 molar hydroxide) were investigated. Cyclic voltammograms and current-voltage curves were obtained by supplying pulses through a potentinstat to a zinc rotating disk electrode. The data are interpreted by treating the system as one with a mixed potential; the processes are termed The zincate and corrosion reactions. The relative proportions of the two processes vary with the supplied potential. For the cathodic region, the cathodic corrosion process predominates at higher potertials while both processes occur simultaneously at a lower potential (i.e., 50 mV). For the anodic region, the anodic zincate process predominates at higher potentials while the anodic corrosion process is dominant at lower potential (i.e., 50 mV) if H2 is present.

N79-30719\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

WIND TURBINES FOR ELECTRIC UTILITIES: DEVELOP-MENT STATUS AND ECONOMICS

J. R. Ramler and R. M. Donovan. 1979. 21 p. refs. Presented at Terrest. Energy Systems Conf., Orlando, Fla., 4-6 Jun. 1979: sponsored by AIAA

(Contract E(49-26)-1028)

(NASA-TM-79170, E-035, DOE/NASA/1028-79/23) Avail: NTIS HC A02/MF A01 CSCL 10B

The technology and economics of the large, horizontal axis wind turbines currently in the Federal Wind Energy Program are presented. Wind turbine technology advancements made in the last several years are discussed It is shown that, based on current projections of the costs of these machines when produced in quantity, they should be attractive for utility application. The cost of electricity (COE) produced at the busbar is shown to be a strong function of the mean wind speed at the installation site. The breakeven COE as a fuel saver is discussed and the COE range that would be generally attractive to utilities is indicated Author

N79-30720°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

PERFORMANCE CHARACTERISTICS OF A SLAGGING GASIFIER FOR MHD COMBUSTOR SYSTEMS Final Report

Kenneth O Smith Jun 1979 49 p refs Sponsored in part by DOE

(Contract EF-77-A-01-2674)

(NASA-TM-79195, E-072, DOE/NASA/2674-79/6) Avail NTIS HC A03/MF A01 CSCL 10A

The performance of a two stage, coal combustor concept for magnetohydrodynamic (MHD) systems was investigated analytically. The two stage MHD combustor is comprised of an entrained flow, slagging gasifier as the first stage, and a gas

phase reactor as the second stage. The first stage was modeled by assuming instantaneous coal devolatilization, and volatiles combustion and char gasification by CO2 and H2O in plug flow. The second stage combustor was modeled assuming adiabatic instantaneous gas phase reactions. Of primary interest was the dependence of char gasification efficiency on first stage particle residence time. The influence of first stage stoichiometry, heat loss, coal moisture, coal size distribution, and degree of coal devolatilization on gasifier performance and second stage exhaust temperature was determined Performance predictions indicate that particle residence times on the order of 500 msec would be required to achieve gasification efficiencies in the range of 90 to 95 percent. The use of a finer coal size distribution significantly reduces the required gasifier residence time for acceptable levels of fuel use efficiency. Residence time requirements are also decreased by increased levels of coal devolatilization Combustor design efforts should maximize devolatilization by minimizing mixing times associated with coal injection. K.L.

N79-31781\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

# DISCHARGE CHARACTERISTICS OF 300 AMPERE-HOUR NI-Zn TRACTION CELLS

John G. Ewashinka Aug. 1979 11 p

(NASA-TM-79244, E-151) Avail NTIS HC - 02/MF A01 CSCL

Preliminary tests were performed on 300 amphere-hour nickel-zinc cells containing the Lewis improved inorganic-organic (I/O) separator. These cells also have other design features included to optimize performance and cycle life. The tests carried out were formation tests and characteristic discharge tests. Information obtained include case temperature and maximum power delivered.

A R H

N79-32640\*# National Aeronautics and Space Administration Lewis Recearch Center, Cleveland, Ohio

#### SOLAR CELL HIGH EFFICIENCY AND RADIATION DAM-AGE, 1979

Aug. 1979 290 p. refs. Conf. held at Cleveland. 13-14 Jun.

(NASA-CP-2097, D-133) Avail NTIS HC A13/MF A01 CSCL 10A

Progress in the effort to increase the end-of-life efficiency of solar cells for space use is assessed. Silicon solar cell efficiency, radiation effects, and gallium arsenide cells are emphasized. For individual titles, see N79-32641 through N79-32673.

N79-32641\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

# THE NASA LEWIS RESEARCH CENTER PROGRAM IN SPACE SOLAR CELL RESEARCH AND TECHNOLOGY

Henry W. Brandhorst, Jr. In its Solar Cell High Efficiency and Radiation Damage, 1979. Aug. 1979. p.1-4 (For primary document see, N79-32640, 23-44).

Avail NTIS HC A13/MF A01 CSCL 10A

Progress in space solar cell research and technology is reported An 18 percent-AMO-efficient silicon solar cell, reduction in the radiation damage suffered by silicon solar cells in space, and high efficiency wrap around contact and thin (50 micrometer) coplanar back contact silicon cells are among the topics discussed Reduction in the cost of silicon cells for space use, cost effective GaAs solar cells the feasibility of 30 percent. AMO solar energy conversion, and reliable encapsulants for space blankets are also considered.

N79-32648\* # Spire Corp. Bedford Mass

#### APPLICATIONS OF ION IMPLANTATION TO HIGH PERFORMANCE, RADIATION TOLERANT SILICON SOLAR CELLS

Allen R. Kirkpatrick, John A. Minnucci, and Keith W. Matthei. In NASA. Lewis Res. Center. Solar Cell High Efficiency and Radiation Damage. 1979. Aug. 1979. p. 51-59. refs. (For primary document see. N79. 32640. 23-44).

(Contracts NAS3-20823; NAS3-21276) Avail: NTIS HC A13/MF A01 CSCL 10A

Progress in the development of ion implanted silicon solar cells is reported. Effective back surface preparation by implantation, junction processing to achieve high open circuit voltages in low-resistivity cells, and radiation tolerance cells are among the topics studied.

J.M.S.

N79-32649\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPEN-CIRCUIT VOLTAGE IMPROVEMENTS IN LOW-RESISTIVITY SOLAR CELLS

Michael P. Godlewski, Thomas M. Klucher, George A. Mazaris, and Victor G. Weizer In its Solar Cell High Efficiency and Radiation Damage, 1979 Aug 1979 p 61-70 refs (For primary document see N79-32640 23-44)

Avail NTIS HC A13/MF A01 CSCL 10A

Mechanisms limiting the open-circuit voltage in 0.1 ohm-cm solar cells were investigated. It was found that a rather complicated multistep diffusion process could produce cells with significantly improved voltages. The voltage capabilities of various laboratory cells were compared independent of their absorption and collection efficiencies. This was accomplished by comparing the cells on the basis of their saturation currents or, equivalently, comparing their voltage outputs at a constant current-density level. The results show that for both the Lewis diffused emitter cell and the Spire ion-implanted emitter cell the base component of the saturation current is voltage controlling. The evidence for the University of Florida cells, although not very conclusive, suggests emitter control of the voltage-Iriniting parameter for the Lewis cell is the electron mobility in the cell base.

N79-32650\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## MODELING OF THIN, BACK WALL SILICON SOLAR CELLS

Cosmo R. Baraona. *In its*. Solar Cell High Efficiency and Radiation Damage, 1979. Aug. 1979. p.73-78. refs (For primary document see. N79-32640, 23-44).

Avail NTIS HC A13/MF A01 CSCL 10A

The performance of silicon solar cells with p-n junctions on the nonilluminated surface (i.e. upside-down or back-wall cells) was calculated These structures consisted of a uniformly shaped p-type substrate layer, a p(+)-type field layer on the front (illuminated) suiface, and a shallow, n-type junction on the back (nonilluminated) surface. A four-layer solar cell model was used to calculate efficiency, open-circuit voltage, and short-circuit current. The effect on performance of p-layer thickness and resistivity was determined. The diffusion length was varied to simulate the effect of radiation damage. The results show that peak initial efficiencies greater than 15 percent are possible for cell thicknesses or 100 micrometers or less. After 10 years of radiation damage in geosynchronous orbit, thin (25 to 50 micro-neters thick) cells made from 10 to 100 ohm cm material show the smallest decrease (approximately 10 percent) in performance

# N79-32653\*# General Electric Co., Schenectady, N. Y. HIGH EFFICIENCY CELL GEOMETRY

R N Hall In NASA Lewis Res Center Solar Cell High Efficiency and Radiation Damage, 1979 Aug 1979 p 97-100 (For primary document see N79-32640 23-44) Avail NTIS HC A13/MF A01 CSCL 10A

A new silicon solar cell is described which has an array of small-area conduction paths to transport corrent directly through the wafer to metal electrodes on the back. This design eliminates grid shadowing and many of the other losses inherent in conventional cells. Early experimental units without texturing or antireflection coatings show 13.3% efficiency under air-mass-one illumination insolation.

Author

N79-32658\* 

Mational Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

RADIATION DAMAGE IN HIGH-VOLTAGE SILICON SOLAR CELLS

Irving Weinberg, Clifford K. Swartz, and Victor G. Weizer In its Solar Cell High Efficiency and Radiation Damage, 1979 Aug. 1979 p 137-143 refs (For primary document see N79-32640 23-44)

Avail NTIS HC A13/MF A01 CSCL 10A

Three types of open circuit high voltage solar cells were tested to determine their performance after exposure to 1 MeV electron irradiations. The cells with a relatively deep n-type emitter were more susceptible to radiation damage than other high prescircuit high voltage cells. The use of diffused or ion implanted junctions leads to open circuit high voltage cell designs that are less susceptible to radiation damage. These latter two types of cells show degradations that are typical of the 0.1 ohm-cm material from which they are fabricated. Furthermore, exposure to ionizing radiation causes oxide degradation and decreased cell performance in cells that depend on a charged oxide to achieve significant cell properties. Hence, the combination of a charged oxide and a relatively deep n-type emitter is not recommended for incorporation into a cell designed for use in the particulate radiation environment of space. MMM

N79-32660°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

## REVERSE ANNEALING IN RADIATION-DAMAGED. SILICON SOLAR CELLS

Irving Weinberg and Clifford K. Swartz. In its Solar Cell High Efficiency and Radiation Damage. 1979. Aug. 1979. p. 161-171 refs. (For primary document see. N79-32640, 23-44). Avail. NTIS. HC. A.13/MF. A01. CSCL. 10A.

In order to understand the results in terms of properties of the radiation induced defects a combination of diffusion length measurements and defect data obtained from Deep Level Transient Spectroscopy were used. The results indicate that the defect at E sub v. + 0.30 eV is responsible for the observed reversed annealing. The defect was identified as a boron-oxygen vacancy complex. This identification is a guide to processing efforts aimed at increasing the concentration of these radiation induced defects. M.M.M.

N7.J-32665\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio

# TEMPERATURE AND INTENSITY DEPENDENCE OF THE PERFORMANCE OF AN ELECTRON-IRRADIATED (AIGa)As/GaAs SOLAR CELL

Clifford K Swartz and Russell E hiux, Jr. In its Solar Cell High Frequency and Radiation Damage, 1979. Aug. 1979 p. 217-226 refs (For primary document see N79-32640-23-44). Avail NTIS HC A13/MF A01. CSCL 10A.

The performance of a Hughes, liquid phase epitaxial 2 centimeter by 2 centimeter. (AIGa)As/GaAs solar cell was measured before and after irradiations with 1 MeV electrons to fluences of 1 x 10 to the 16th power electrons/sq cm. The temperature dependence of performance was measured over the temperature range 135 to 415 K at each fluence level. In addition, temperature dependences were measured at five intensity levels from 137 to 2.57 mW/sq cm before irradiation and after a fluence of 1 x 10 to the 16th power electrons/sq cm. For the intermediate fluences, performance was measured as a function of intensity at 298 K only.

Gry

# N79-32666\*# Lincoln Lab. Mass Inst of Tech., Lexington SHALLOW-HOMOJUNCTION GBAs SOLAR CELLS

John C. C. Fan. In NASA. Lewis Res. Center. Solar Cell High Frequency and Radiation Damage. 1979. Aug. 1979. p. 227-233 refs. Sponsored in part by AF. (For primary document see N79-32640-23-44).

Avail NTIS HC A13/MF A01 CSCL 10A

Single-crystal GaAs shallow-homojunction solar cells on GaAs or Ge substrates without Ga sub 1 x Al sub x As window layers, that have conversion efficiencies exceeding 20% at AM1.

(17% at AMO). Using a simple theoretical model, good fits were obtained between computer calculations and experimental data for external quantum efficiency and conversion efficiency of cells with different values of n± layer thickness. The calculations not only yield values for material properties of the GaAs layers composing the cells but will also permit the optimization of cell designs for space and terrestrial applications. Preliminary measurements indicate that the shallow-homojunction cells are resistant to electron irradiction. In the best test so far, bombardment with 1 x 10 to the 16th power/sq cm fluence of 1 MeV electrons reduced the short-circuit current by only about 6%.

GY

# N79-32669\* Hughes Research Labs., Malibu, Calif. SUMMARY OF GaAs SOLAR CELL PERFORMANCE AND RADIATION DAMAGE WORKSHOP

G S Kamath *In* NASA. Lewis Res. Center Solar Cell High Efficiency and Radiation Damage, 1979 Aug. 1979 p 253-254 (For primary document see N79-32640 23-44)

Avail NTIS HC A13/MF A01 CSCL 10A

The workshop considered the GaAs solar cell capability and promise in several steps. (1) maximum efficiency. (2) space application (3) major technology problems (AR coating optimization, contacts). (4) radiation resistance, (5) cost and availability, and (6) alternatives. The workshop believes that GaAs solar cells are fast approaching the fulfillment of their potential as candidates for space cells. A maximum efficiency of 20 to 31 percent AMO can be reasonably expected from GaAs based cells, and this may go a little higher with concentration. The use of concentration in space needs to be more carefully evaluated.

GY

N79-33572°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

# ANNEALING OF RADIATION DAMAGE IN 0.1- AND 2-OHM-CENTIMETER SILICON SOLAR CELLS

Irving Weinberg and Clifford K. Swartz. Oct. 1979. 13 p. refs. (NASA-TP 1559, E-9997). Avail. NTIS. HC A02/MF A01. CSCL 10A.

Isochronal and isothermal annealing studies were conducted on 0.1 and 2 ohm centimeter n(+)/p silicon cells after irradiation by 1 MeV electrons at fluences of 10 to the 14th power. 5 times 10 to the 14th power and 10 to the 15th power per square centimeter For the 0.1 ohm centimeter cells, reverse annealing was not observed in the isochronal data. However, reverse annealing was observed between approximately 200 and 325 C in the isochronal data of the 2 ohm centimeter cells. Isothermal annealing of 0.1 ohm centimeter cells at 500 C restored pre-irradiation maximum power P sub max within 20 minutes at fluence = 10 to the 14th power, in 180 minutes at fluence 5 times 10 to the 14th power and to 92 percent of pre-irradiation P sub max in 180 minutes for fluence = 10 to the 15th power Annealing at 450 C was found inadequate to restore 0.1 ohm centimeter cell performance within reasonable times for all fluence levels. By comparison, at 450 C, the P sub max of 2 ohm centimeter cells was restored within 45 minutes. for the two highest fluence levels, while for the lowest fluence. restoration was completed within 15 minutes. Spectral response data indicate that, for both resistivities, degradation occurs predominantly in the cells p-type base region Author

A79-10084 \* Rapid, efficient charging of lead-acid and nickel zinc traction cells. J. J. Smithrick (NASA, Lewis Research Center, Cleveland, Ohio). In Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20.25, 1978. Proceedings. Volume 1. (A79-10001-01-44). Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 672-676, 6 refs. NASA supported research, Contract No. EC-77, A.31-1011.

Lead and and mickelizing traction cells were rapidly and efficiently charged using a high rate taped do charge (HRTDC) method which could possibly be used for on the road service recharge of electric vehicles. The HRTDC method takes advantage of initial high cell charge acceptance and uses cell gassing rate and temperature as an indicator of charging efficiency. On the average,

300 amp-hour nickel-zinc traction cells were given a HRTDC to 78% of rated amp-hour capacity within 53 minutes at an amp-hour efficiency of 92% and an energy efficiency of 52%. Three-hundred amp-hour lead-acid traction cells were charged to 69% of rated amp-hour capacity within 46 minutes at an amp-hour efficiency of 91% with an energy efficiency of 64%.

A79-10097 \* Response of lead-acid batteries to choppercontrolled discharge. R. L. Cataldo (NASA, Lewis Research Center, Cleveland, Ohio). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings. Volume 1. (A79-1001-01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 764-768.

The results of tests on an electric vehicle battery, using a simulated electric vehicle chapper-speed controller, show energy output losses up to 25 percent compared to constant current discharges at the same average current of 100 A. However, an energy output increase of 22 percent is noticed at the 200 A average level and 44 percent increase at the 300 A level using pulse discharging. Because of these complex results, electric vehicle battery/speed controller interactions must be considered in vehicle design. (Author)

A79-10101 \* Thermal energy storage for industrial waste heat recovery. H. W. Hoffman, R. J. Kedl (Oak Ridge National Laboratory, Oak Ridge, Tenn.), and R. A. Duscha (NASA, Lewis Research Center, Cleveland, Ohio). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings. Volume 2. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 910-916. NASA-supported research. Contract No. W-7405-eng-26.

Thermal energy storage systems designed for energy conservation through the recovery, storage, and reuse of industrial process waste heat are reviewed. Consideration is given to systems developed for primary aluminum, cement, the food processing industry, paper and pulp, and primary iron and steel. Projected waste-heat recovery and energy savings are listed for each category. S.C.3.

A79-10108 \* Storage systems for solar thermal power, J. E. Calogeras and L. H. Gordon (NASA, Lewis Research Center, Cleveland, Ohio). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings, Volume 2. (A79-10001-01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 970-976, 11 refs.

A major constraint to the evolution of solar thermal power systems is the need to provide continuous operation during periods of solar outage. A number of high temperature thermal energy storage technologies which have the potential to meet this need are currently under development. The development status is reviewed of some thermal energy storage technologies specifically oriented towards providing diurnal heat storage for solar central power systems and solar total energy systems. These technologies include sensible heat storage in caverns and latent heat storage using both active and passive heat exchange processes. In addition, selected thermal storage concepts which appear promising to a variety of advanced solar thermal system applications are discussed. (Author)

A79 10113 \* Lithium and potassium heat pipes for thermionic converters. G. Miskolczy. (Thermo Electron Corp., Waltham, Mass.) and E. Kroeger (NASA, Lewis Research Center, Cieveland, Ohio). In Intersociety Energy Conversion Engineering Conference, 13th. San Diego, Calif. August 20:25, 1978. Proceedings. Volume 2. (A79 10001 01:44). Warrendale, Pa., Society of Automative Engineers, Inc., 1978. p. 1035-1039. 5-refs. Contract No. NAS3 20270.

A prototypic heat pipe system for all out of core thermionic reactor has been built and tested. The emitter of the concentric thermionic converter consists of the condenser of a tungsten heat pipe utilizing a lithium working fluid. The evaporator section of the emitter heat pipe is radiation heated to simulate the thermal input.

from the nuclear reactor. The emitter heat pipe thermal transport is matched to the thermionic converter input requirement. The collector heat pipe of niobium, 1%-zirconium alloy uses potassium as the working fluid. The thermionic collector is coupled to the heat pipe by a tapered conical joint designed to minimize the temperature drop. The area ratio of the evaporator to condenser is 16:1, which increases the radiation area. The composite wick structure consists of seven arteries and cylindrical wraps. The collector heat flux matches the design requirements of the thermionic converter. (Author)

A79-10234 \* Design and operating experience on the U.S. Department of Energy Experimental Mod-O 100 kW Wind Turbine. J. C. Glasgow and A. G. Birchenough (NASA, Lewis Research Center, Cleveland, Ohio). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Callif, August 20-25, 1978, Proceedings. Volume 3. (A79-10001 01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 2052-2059. 5 refs.

The Mod-O 10G kW Experimental Wind Turbine was designed and fabricated by NASA, as part of the Federal Wind Energy Program, to assess technology requirements and engineering problems of large wind turbines. The machine became operational in October 1975 and has demonstrated successful operation in all of its design modes. During the course of its operations the machine has generated a wealth of experimental data and has served as a prototype developmental test bed for the Mod-OA operational wind turbines which are currently used on utility networks. This paper describes the mechanical and control systems as they evolved in operational tests and describes some of the experience with various systems in the downwind rotor configuration. (Author)

A79-10235 \* DOE/NASA Mod-OA wind turbine performance. T. R. Richards and H. E. Neustadter (NASA, Lewis Research Center, Cleveland, Ohia) In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings. Volume 3. (A79-10001-01-44) Warrendale, Pa., Society of Automative Engineers, Inc., 1978, p. 2060-2063. 11 refs.

The NASA Lew?- Research Center has designed, built, and is operating a 200-kW wind turbine (designated the Mod-OA-1) at Clayton, New Mexico. This paper compares the measured power-vs-speed performance of the Mod-OA-1 with predictions made using the PROP code. It is found that the actual performance closely matches predictions.

B.J.

A79-10241 \* SIMWEST - A simulation model for wind energy storage systems. R. W. Edsinger, A. W. Warren (Bueing Computer Services, Inc., Seattle, Wash.), L. H. Gordon (NASA, Lewis Research Center, Cleveland, Onio), and G. C. Chang (U.S. Department of Energy, Washington, D.C.). In: Intersociety Energy Conversion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings. Volume 3. (A79-10001 01-44) Warrendale, Pai, Society of Automotive Engineers, Inc., 1978, p. 2108-2114

This papers describes a comprehensive and efficient computer program for the modeling of wind energy systems with storage. The level of detail of SIMWEST (SImulation Model for Wind Energy STorage) is consistent with evaluating the economic feasibility as well as the general performance of wind energy systems with energy storage options. The software package consists of two basic programs and a library of system, environmental, and control components. The first program is a precompiler which allows the library components to be put together in building block form. The second program performs the technoeconomic system analysis with the required input/output, and the integration of system dynamics. An example of the application of the SIMWEST program to a current 100 kW wind energy storage system is given.

A79-11824 \* Factors affecting the open-circuit voltage and electrode kinetics of some iron/titanium/redox flow cells. M. A. Reid and R. F. Gahn (NASA, Lewis Research Center, Cleveland, Ohio: In: Symposium on Electrode Materials and Processes for Energy Conversion and Storage, Philadelphia, Pa., May 9-12, 1977, Proceedings. (A79-11776 02-25) Princeton, N.J., Electrochemical Society, Inc., 1977, p. 732-749. 10 refs. Contract No. E(49-28)-1002.

The effect of acid concentration on the performance of the iron-titanium redox flow cell was studied. When the acidity was increased, open-circuit voltages decreased on the titanium side but load voltages increased due to decreased polarization. The best load voltage occurs when there is high acidity on the titanium side coupled with low acidity on the iron side, but such cells show voltage losses with repeated cycling because of the diffusion of acid through the membrane. No membrane tested has been found capable of maintaining the differences in acidity. Chelating agents show some promise in reducing polarization at the Ti electrode and thus improving energy efficiency.

M.L.

A79-13098 \* # Diminiode thermionic energy conversion with lanthanum-hexaboride electrodes. E. W. Kroeger, V. L. Bair, and J. F. Morris (NASA, Lewis Research Center, Cleveland, Ohio). Institute of Electrical and Electronics Engineers, International Conference on Plasma Science, Monterey, Calif., May 15-18, 1978, Paper. 17 p. 41 refs.

This paper presents thermionic-conversion data obtained from a variable-gap cesium diminiode with a hot-pressed, sintered lanthanum-hexaboride emitter and an arc-melted lanthanum-hexaboride collector. Performance curves cover a range of temperatures: emitter 1500 to 1700 K, collector 750 to 1000 K, and cesium reservoir 370 to 510 K. Calculated values of emitter and collector work functions and barrier index are also given. (Author)

A79-13099 \* # Optimize out-of-core thermionic energy conversion for nuclear electric propulsion. J. F. Morris (NASA, Lewis Research Center, Thermionics and Heat Pipe Section, Cleveland, Ohio). Institute of Electrical and Electronics Engineers, International Conference on Plasma Science, Monterey, Calif., May 15-18, 1978, Paper, 14 p. 14 refs.

Thermionic energy conversion (TEC) potentialities for nuclear electric propulsion (NEP) are examined. Considering current designs, their limitations, and risks raises critical questions about the use of TEC for NEP. Apparently a reactor cooled by hotter than 1675 K heat pipes has good potentialities. TEC with higher temperatures and greater power densities than the currently proposed 1650 K, 5 to 6 W/sq cm version offers substantial gains. Other approaches to high-temperature electric isolation appear also promising. A high-power-density, high-temperature TEC for NEP appears, therefore, attainable. It is recommended to optimize out-of-core thermionic energy conversion for nuclear electric propulsion. Although current TEC designs for NEP seem unnecessary compared with Brayton versions, large gains are apparently possible with increased temperatures and greater power densities.

A79-13867 \* # NASA Lewis Research Center photovoltaic application experiments. A. Ratajczak, W. Bifano, J. Martz, and P. O'Donnell (NASA, Lewis Research Center, Cloveland, Ohio). American Institute of Aeronautics and Astronautics and Arizona Solar Energy Research Commission, Conference on Solar Energy. Technology Status, Phoenix, Ariz., Nov. 27.29, 19.8. AIAA Paper 78.1768.

The NASA Lewis Research Center has installed 16 geographically dispersed terrestrial photovoltaic systems as part of the DOE National Photovoltaic Program. Four additional experiments are in progress. Currently, operating systems are powering refrigerators, a highway warning sign, forest lookout towers, remote weather stations, a water chiller and insect survey traps. Experiments in progress include the world's first village power system, an air pollution monitor and seismic sensors. Under a separate activity

funded by the U.S. Agency for International Development, a PV-powered water pump and grain grinder is being prepared for an African village. System descriptions and status are included in this report.

(Author)

A79-14947 \* # Fuel cell on-siče integrated energy system parametric analysis of a residential complex. S. N. Simons (NASA, Lewis Research Center, Cleveland, Ohio). U.S. Department of Energy, Fuel Cell Workshop, Sarasota, Fla., Nov. 14-17, 1977, Paper. 24 p. 7 refs.

The use of phosphoric acid fuel cell powerplant to provide all the electricity required by an 81-unit garden apartment complex is utudied. Byproduct heat is recovered and provides some of the heat required by the complex. The onsite integrated energy system contains energy conversion equipment including combinations of compression and absorption chillers, heat pumps, electric resistance heaters, and thermal storage. The annual fuel requirement for several onsite integrated energy systems as well as the fuel cell breakeven cost for one specific system were calculated. It is found that electrical efficiency cannot be traded off against thermal efficiency without paying a penalty in system efficiency.

M.L.

A79-15574 \* Control of wind turbine generators connected to power systems. H. H. Hwang, H. V. Mozeico (Hawaii, University, Honolulu, Hawaii), and L. J. Gilbert (NASA, Lewis Research Center, Cleveland, Ohio). In: Power system control and protection. New York, Academic Press, Inc., 1978, p. 239-259. 16 refs. Research supported by the Hawaii Natural Energy Institute and NASA.

A unique simulation model based on a Mode-O wind turbine is developed for simulating both speed and power control. An analytical representation for a wind turbine that employs blade pitch angle feedback control is presented, and a mathematical model is formulated. For Mode-O serving as a practical case study, results of a computer simulation of the model as applied to the problems of synchronization and dynamic stability are provided. It is shown that the speed and output of a wind turbine can be satisfactorily controlled within reasonable limits by employing the existing blade pitch control system under specified conditions. For power control, an additional excitation control is required so that the terminal voltage, output power factor, and armature current can be held within narrow limits. As a result, the variation of torque angle is limited even if speed control is not implemented simultaneously with power control. Design features of the ERDA/NASA 100-kW Mode-O wind turbine are included.

A79-15881 • Large wind turbine generators. R. L. Thomas and R. M. Donovon (NASA, Lewis Research Center, Cleveland, Ohio). In: Energy technology V: Challengas to technology, Proceedings of the Fifth Conference, Washington, D.C., February 27-March 1, 1978. (A79-15879 04-44) Washington, D.C., Government Institutes, Inc., 1978, p. 64-82. 17 refs.

The large wind turbine portion of the Federal Wind Energy Program consists of two major project efforts: (1) the Mod-0 test bed project for supporting research technology, and (2) the large experimental wind turbines for electric utility applications. The Mod-0 has met its primary objective of providing the entire wind energy program with early operations and performance data. The large experimental wind turbines to be tested in utility applications include three of the Mod-0A (200 kW) type, one Mod-1 (2000 kW), and possibly several of the Mod-2 (2500 kW) designs. This paper presents a description of these wind turbine systems, their programmatic status, and a summary of their potential costs.

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A79-20828 \* Wind-turbine-generator rotor-blade concepts with low-cost potential. T. L. Sullivan, T. P. Cahill (NASA, Lewis Research Center, Cleveland, Ohio), D. G. Criffee, Jr. (NASA, Lewis Research Center, Cleveland, Ohio; United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.), and H. W. Gewehr (NASA, Lewis Research Center, Cleveland, Ohio; Kaman Aerospace Corp., Bloomfield, Conn.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 428-456.

Four processes for producing blades are examined. Two use filament winding techniques and two involve filling a mold or form to produce all or part of a blade. The processes are described and a comparison is made of costs, material properties, designs and free vibration characteristics. Conclusions are made regarding the feasibility of each process to produce low-cost, structurally adequate blades.

(Author)

A79-20829 An operating 200 kW horizontal axis wind turbine. C. L. Hunnicutt (Lockheed Aircraft Service Co., Ontario, Calif.), B. Linscott, and R. A. Wolf (NASA, Lewis Research Center, Cleveland, Ohio). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Seciety for the Advancement of Material and Process Engineering, 1978, p. 457-478.

Output from the 200-kilowatt machine will be enough to meet the power requirements of about 60 families. The experimental wind turbine generator (WTG) is a two-bladed, horizontal-axis, rotor system driving a synchronous electric generator through a step-up gear box located within a nacelle. The nacelle is mounted on top of a 100-foot tower with the rotor located downwind from the tower. The 200-kilowatt rated power output of the wind turbine is achieved at a turbine rotor speed of 40 rpm and a rated wind speed of 18.3 mph. The rated wind speed is defined as the lowest wind speed at which full power is achieved. Attention is given to operational details, aspects of blade design, blade fabrication, the use of strain gages, questions of aeroelastic stability, and an early analysis of test data.

G.R.

A79-21300 \* # Thermal storage for industrial process and reject heat. R. A. Duscha and W. J. Masica (NASA, Lewis Research Center, Cleveland, Ohio). U.S. Department of Energy, Conference on Waste Heat Management and Utilization, 2nd, Miami Beach, Fla., Dec. 4-6, 1978, Paper. 12 p. 7 refs. Contract No. EC-77-A-31-1034.

industrial production uses about 40% of the total energy consumed in the United States. The major share of this is derived from fossil fuel. Potential savings of scarce fuel is possible through the use of thermal energy storage (TES) of reject or process heat for subsequent use. Results of study contracts awarded by the Department of Energy (DOE) and managed by the NASA Livis Research Center have identified three especially significant industries where high temperature TES appears attractive - paper and pulp, iron and steel, and cement. Potential annual fuel savings with large scale implementation of near-term TES systems for these three industries is nearly 0 million bbl of oil. (Author)

A79-21302 \* " Microprocessor control of a wind turbine generator. A. J. Gnecco and G. T. Whitehead (NASA, Lewis Research Center, Cleveland, Ohio). Institute of Electrical and Electronics Engineers, Conference on Industrial Applications of Microprocessors, Philades, via. Pa. Mai. 20.22, 1978, Paper. 15 p. Contract. No E(49.26):1028.

This paper describes a microprocessor based system used to control the unattended operation of a wind turbine generator. The turbine and its microcomputer system are fully described with special emphasis on the wide variety of tasks performed by the microprocessor for the safe and efficient operation of the turbine.

The flexibility, cost and reliability of the microprocessor were major factors in its selection. (Author)

A79-26131 \* # Photovoltaic power systems for rural areas of developing countries. L. Rosenblum, W. J. Bifano, G. F. Hein, and A. F. Ratajczak (NASA, Lewis Research Center, Cleveland, Ohio). United Nations, International Seminar on Solar Energy, Tokyo, Japan, Feb. 5-10, 1979, Paper. 18 p. 9 refs.

Photovoltaic (PV) applications for rural areas of underdeveloped countries are discussed in relation to PV system technology, reliability, and present and projected cost. The information presented is derived mainly from NASA, Lewis Research Center experience with PV systems deployed with a variety of users for applications relevant to LDCs. A detailed description of two village power systems is included. Energy cost comparisons are presented for PV systems versus alternative energy sources. It is concluded, bared on present PV system technology, reliability and cost that photovoltaics provides a realistic energy option for LDCs in both the near and far-term. (Author)

A79-30554 \* # Benefits of solar/fossil hybrid gas turbine systems. H. S. Bloomfield (NASA, Lewis Research Center, Cleveland, Ohio). American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-38. 16 p.

The potential benefits of solar/fossil hybrid gas turbine power systems were assessed. Both retrofit and new systems were considered from the aspects of cost of electricity, fuel conservation, operational mode, technology requirements, and fuels flexibility. Hybrid retrofit (repowering) of existing combustion (simple Brayton cycle) turbines can provide near-term fuel savings and solar experience, while new and advanced recuperated or combined cycle systems may be an attractive fuel saving and economically competitive whicle to transition from today's gas and oil-fired power-plants to other more abundant fuels. (Author)

A7938191 \* // Redox flow cell energy storage rystems. L. H. Thaller (NASA, Lewis Research Center, Solar and Electroclemistry Div., Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0989. 9 p. 7 refs. Contract No. E(49-28)-1002.

The redox flow cell energy storage system being developed by NASA for use in remote power systems and distributed storage installations for electric utilities is presented. The system under consideration is an electrochemical storage device which utilizes the oxidation and reduction of two fully soluble redox couples (ac-dified chloride solutions of chromium and iron) as active electrode materials separated by a highly selective ion exchange membrane The reactants are contained in large storage tanks and pumped through a stack of redox flow cells where the electrochemical reactions take place at porous carbon felt electrodes. Redox equipment has allowed the incorporation of state of charge readout, stack voltage control and system capacity maintenance (rebaiance) devices to regulate cells in a stack jointly. A 200 W, 12 V system with a capacity of about 400 Wh has been constructed, and a 2 kW, 10kWh system is planned ALW

A7938192 \* # Araiysis of a fuel cell on site integrated energy system for a residential complex. S. N. Simons (NASA, Lewis Research Center, Fuel Cell Projects Office, Cleveland, Ohio) and W. L. Maag (Solar Energy Products Co. Avon. Lake, Ohio). American Institute of Aeronautics and Asironautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0990. 10 p. 8 refs.

The energy use and costs of the on-site integrated energy system (OS/IES) which provides electric power from an on-site power plant and recovers heat that would normally be rejected to the environ-

ment is compared to a conventional system purchasing electricity from a utility and a phosphoric acid fuel cell powered system. The analysis showed that for a 500-unit apartment complex a fuel OS/IES would be about 10% more energy conservative in terms of total coal consumption than a diese. OS/IES system or a conventional system. The fuel cell OS/IES capital costs could be 30 to 55% greater than the diesel OS/IES capital costs for the same life cycle costs. The life cycle cost of a fuel cell OS/IES would be lower than that for a conventional system as long as the cost of electricity is greater than \$0.05 to \$0.065/kWh. An analysis of several parametric combinations of fuel cell power plant and state-of-art energy recovery systems and annual fuel requirement calculations for four locations were made. It was shown that OS/IES component choices are a major factor in fuel consumption, with the least efficient system using 25% more fuel than the most efficient. Central air conditioning and heat pumps result in minimum fuel consumption while individual air conditioning units increase it, and in general the fuel cell of highest electrical efficiency has the lowest fuel consump-

A79-38888 \* # Wind turbines for electric utilities - Development status and economics, J. R. Ramler and R. M. Donovan (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0965. 19 p. 15 refs.

The technology and economics of the large, horizontal-axis wind turbines currently in the Federal Wind Energy Program are presented. Wind turbine technology advancements made in the last several years are discussed, It is shown that, based on current projections of the costs of these machines when produced in quantity, they should be attractive for utility application. The cost of electricity (COE) produced at the bic bar is shown to be a strong function of the mean wind speed at the installation site. The breakeven COE as a 'fuel saver' is discussed and the COE range that would be generally attractive to utilities is indicated. (Author)

A79-40398 \* # Ultraviolet irradiation at elevated temperatures and thermal cycling in vacuum of FEP-A covered silicon solar cells. J. D. Broder and S. J. Marsik (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. (A79-40881-17-44). New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 122-126-9 refs.

Silicon solar cells covered with FEP-A were irradiated in vacuum with ultraviolet light and then subjected to thermal cycling. These accelerated laboratory conditions are believed to be equivalent to those experienced by FEP-A covered cells on the ATS-6 spacecraft and the results indicate a probable mechanism for the faster degradation of the FEP-A covered cells. Heat-bonded FEP-A covers apparently embrittle when exposed to four months of space UV radiation at elevated temperatures, and crack when subjected to thermal cycling during the eclipse period. Low energy proton radiation can then penetrate to the junction of the cell causing degradation of the open circuit voltage and maximum power to occur. An alternate method of application of FEP-A, such as with adhesives, may prevent such cracking.

A79-41022 \* # Endurance testing of first generation /Block I/commercial solar cell modules. E. Anagnostou and A. F. Forestieri (NASA, Lewis Research Center Cleveland, Ohio). In Photovoltaic Specialists. Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. (A79-40881-17-44). New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 843-846. Contract No. E(49-26) 1022.

NASA LeRC has conducted outdoor endurance tests on modules commercially produced as part of the 46 kW purchase of first generation (Block I) modules by the JPL Low Cost Silvon Solar Array Project. Block I modules from four manufacturers were installed at commercial testing sites in Florida, Puerto Rico and Arizona and at noncommercial sites in Cleveland, Ohio. The

conditions endured by these modules included hot and dry, hot and humid, tropical rain forest, sea-air, urban industrial and urban clean; exposures were for periods up to one year. Test results are presented and discussed.

B.J.

A79-41023 ° # Variation of solar cell sensitivity and solar ractiation on tilted surfaces. T. M. Klucher (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. (A79-40881 17-44). New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 847-852. Contract No. E(49-26)-1022.

An empirical study was performed (1) to evaluate the validity of various insolation models used to compute solar radiation incident on titled surfaces from global data measured on horizontal surfaces and (2) to determine the variation of solar cell sensitivity to solar radiation over a wide range of atmospheric condition. Evaluation of the insolation data indicates that the isotropic sky model of Liu and Jorden undurestimates the amount of solar radiation falling on titled surfaces by as much as 10%. An anisotropic-clear-sky model proposed by Temps and Coulson was also evaluated and found to be deficient under cloudy conditions. A new model, formulated herein, reduced the deviations t atween measured and predicted insolation to less than 3%. Evaluation of solar cell sensitivity data indicates small change (2-3%) in sensitivity from winter to summer firstilled cells. The feasibility of using such global data as a means fic celibrating terrestrial solar cells as done by Treble is discussed. (Author)

A79-41047 \* # An inverter/controller subsystem optimized for photovoltaic applications. R. L. Pickrell, W. C. Merrill (NASA, Lewis Research Center, Cleveland, Ohio), and G. O'Sullivan (Abacus Controls, Inc., Somerville, N.J.). In Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. (A79-40881 17 44) New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 984-991. 5 refs.

Conversion of solar array dc power to ac power stimulated the specification, design, and simulation testing of an inverter/controller subsystem tailored to the photovoltaic power source characteristics. This paper discusses the optimization of the inverter/controller design as part of an overall Photovoltaic Power System (PPS) designed for maximum energy extraction from the solar array. The special design requirements for the inverter/controller include: (1) a power system controller (PSC) to control continuously the solar array operating point at the maximum power level based on variable solar insolation and cell temperatures, and (2) an inverter designed for high efficiency at rated load and low losses at light loadings to conserve energy. It must be capable of operating connected to the utility line at a level set by an external controller (PSC). (Author)

A79-41089 \* // Design and fabrication of a photovoltaic power system for the Papago Indian Village of Schuchuli /Gunsight/, Arizona. W. J. Bifano, A. F. Ratajczak, and W. J. Ice (NASA, Lewis Research Center, Cleveland, Ohio). In Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record (A79-40881 17-44). New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1262 1267.

A79-41091 \*\* Description and status of NASA-LERC/DOE photovoltaic applications systems experiments. A F Ratajczak (NASA, Lewis Research Center, Cleveland, Ohio) In Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. (A79-40881 17-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1272-1277. Contract No. E(49-26) 1022.

In its role of supporting the DOE Photovoltaic Program, the NASA-Lewis Research Center has designed, fabricated and installed 16 geographically dispersed photovoltaic systems. These systems are powering a refrigerator, highway viurning sign, forest lookout towers, remote weather stations, a water chiller at a visitor center, and insect

survey traps. Each of these systems is described in terms of load requirements, solar array and battery size, and instrumentation and controls. Operational experience is described and present status is given for each system. The P/V power systems have proven to be highly reliable with almost no problems with modules and very few problems overall. (Author)

A79-41098 • # Photon degradation effects in terrestrial solar cells. V. G. Weizer, H. W. Brandhorst, J. D. Broder, R. E. Hart, and J. H. Lamneck (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1973, Conference Record. (A79-40881 17-44) New York. Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1327-1332, 10 refs.

A certain type of photon degradation effect has been observed experimentally in n(+)/p solar rells. It is found that this effect is caused by a recombination center, the formation of which requires the simultaneous presence of a lattice defect and a silver atom or complex of atoms. The center is electrically active in its equilibrium state; the energy level of the inactive center is located in the band gap, 0.37 eV below the conduction band. Conversion to an active recombination center can be brought about either by raising the minority carrier quasi-Fermi level to coincide with the position of the latent center level in the band gap or by the direct excitation of electrons from the valence band to the latent center level. Photon degradation can be prevented either by preventing the introduction of silver through the use of a clean diffusion system and clean initial material or by eliminating lattice damage through sufficient surface material removal prior to diffusion while at the same time restricting diffusion temperatures to 875 C or below. L.S

A79-42545 \* Photon-degradation effects in cerrestrial silicon solar cells. V. G. Weizer, H. W. Brandhorst, J. D. Broder, R. E. Hart, and J. H. Lamneck (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Applied Physics*, vol. 50. June 1979, p. 4443-4449, 10 refs. Contract No. EX. 76-A-29 1002.

The effect of instability in terrestrial solar cells and identification of mechanisms involved are presented. The effect is similar to photon-induced degradation in radiation-damaged space solar cells, with reduction in cell output in n(+)/p cells upon exposure to illumination or upon the application of a sufficiently high forward bias. It was found that the photon-degradation effect is caused by a recombination center identified as a complex of a lattice defect and a silver atom or cluster of atoms. The center is electrically inactive in its ground state but can be activated by raising the minority-carrier quasi-Fermi level to coincide with the position of the latent-center level in the band gap, or by direct excitation of electrons from the valence band to the latent-center 'evel. Photon degradation can be prevented by avoiding the introduction of silver through the use of a clean diffusion system and clean initial material, or by eliminating lattice damage by sufficient surface material removal prior to diffusion and restricting diffusion temperatures to 875 C or below.

A79-44225 \* # Energy and cost savings results for advanced technology systems from the Cogeneration Technology Alternatives Study /CTAS/. G. D. Sagerman, G. J. Barna, and R. K. Burns (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla. June 4-6, 1979, Paper 79-1000, 20 p. Contract No. EC-17-A 31 1062.

The Cogeneration Technology Alternatives Study (CTAS), a program undertaken to identify the most attractive advanced energy conversion systems for inJustrial cogeneration applications in the 1985-2000 time period, is described, and preliminary results are presented. Two cogeneration options are included in the analysis: a topping application, in which fuel is input to the energy conversion system which generates electricity and waste heat from the conversion system is used to provide heat to the process, and a cottoming application, in which fuel is burned to provide high temperature

process heat and waste heat from the process is used as thermal input to the energy conversion system which generates energy. Steam turbines, open and closed cycle gas turbines, combined cycles, diesel engines, Stirling engines, phosphoric acid and molten carbonate fuel cells and thermionics are examined. Expected plant level energy savings, annual energy cost savings, and other results of the economic analysis are given, and the sensitivity of these results to the assumptions concerning fuel prices, price of purchased electricity and the potential effects of regional energy use characteristics is discussed.

C.K.D.

A79-46527 \* # Large horizontal axis wind turbine development. W. H. Robbins and R. L. Thomas (NASA, Lewis Research Center, Cleveland, Ohio). In: Workshop on Economic and Operational Requirements and Status of Large Scale Wind Systems, Monterey, Calif., March 28-30, 1979, Proceedings. (A79-46526 20-44) Santa Cruz, Calif., Altas Corp., 1979, p. 50-70; Discussion, p. 71, 72.

The paper presents an overview of the NASA activities in large horizontal axis wind turbine development. First generation technology large wind turbines (Mod-0A, Mod-1) have been designed and are in operation at selected utility sites. Second generation machines (Mod-2) are scheduled to begin operations on a utility site in 1980. These machines are estimated to generate electricity at less than 4 cents/kWh when manufactured in modest production rates. Meanwhile, plans are being made to continue developing wind turbines which can meet the cost goals of 2 to 3 cents/kWh. V.T.

A79-46537 • Utility operational experience on the NASA/DOE Mod-OA 200 kW Wind Turbine. J. C. Glasgow and W. H. Robbins (NASA, Lewis Research Center, Cleveland, Ohio, In: Workshop on Economic and Operational Requirements and Status of Large Scale Wind Systems, Monterey, Calif., March 28-30, 1979, Proceedings. (A79 46526 20:44) Sunta Cruz, Chin., Altas Corp., 1979, p. 215-245; Discussion, p. 246-247-6 rcfs.

The Mod-OA 200 kW Wine: Turbine was designed and fabricated by the Lewis Research Center of the NASA under the direction of the U.S. Department of Energy. The project is a part of the Federal Wind Energy Program and is designed to obtain early wind turbine operation and performance data while gaining initial experience in the operation of large, horizontal axis wind turbines in typical utility environments. On March 6, 1978, the Mod-OA wind turbine was turned over to the Town of Clayton Light and Water Plant, Clayton, NM, for utility operation and on December 31, 1978 the machine had completed ten months of utility operation. This paper describes the machine and documents the recent operational experience at Clayton, NM.

(Author)

A79-46547 \* # Lewis Research Center studies of multiple large wind turbine generators on a utility network. L. J. Gilbert (NASA, Lewis Research Center, Cleveland, Ohio) and D. M. Triezenberg (Purdue University, West Lafayette, Ind.), In: Workshop on Economic and Operational Requirements and Status of Large Scale Wind Systems, Monterey, Calif., March 28-30, 1979, Proceedings. (A79-46526-20-44) Santa Cruz, Calif., Altas Corp., 1979, p. 388-402, 5 refs.

A NASA-Lewis program to study the anticipated performance of a wind turbine generator farm on an electric utility network is surveyed. The paper describes the approach of the Lewis Wind Energy Project Office to developing analysis capabilities in the area of wind turbine generator-utility network computer simulations. Attention is given to areas such as, the Lewis Purdue hybrid simulation, an independent stability study. DOE multiunit plant study, and the WEST simulator. Also covered are the Lewis mod-2 simulation including analog simulation of a two wind turbine system and comparison with Boeing simulation results, and gust response of a two machine model. Finally future work to be done is noted and it is concluded that the study shows little interaction between the generators and between the

A79-47651 \* # A mobile apparatus for solar collector testing. G. B. Hotchkiss (Texas Instruments, Inc., Dallas, Tex.), F. F. Simon (NASA, Lewis Research Center, Cleveland, Ohio), and L. C. Burmeister (Kansas, University, Lawrence, Kan.). American Society of Mechanical Engineers, Design Engineering Conference and Show, Chicago, Ill., May 7-10, 1979, Paper 79-DE-5. 6 p. 14 refs. Grant No. NsG 3087.

The design, construction, and operation of a mobile apparatus for solar collector testing (MASCOT) is describeri. The MASCOT is a self-contained test unit costing about \$10,000 whose only external requirement for operation is electrical power and which is capable of testing two water-cooled flat-plate solar collectors simultaneously. The MASCOT is small enough and light enough to be transported to any geographical site for outdoor tests at the location of collector usage. It has been used in both indoor solar simulator tests and outdoor tests.

(Author)

A79-49527 \* # Reduction of particulate carryover from a pressurized fluidized bed. R. W. Patch (NASA, Lewis Research Center, Cleveland, Ohio). Symposium on the Transfer and Utilization of Particulate Control Technology, 2nd, Denver, Colo., July 23-27, 1979 Paper, 20 p.

A bench-scale pressurized fluidized bed combustor (PFBC) constructed with a conical shape to reduce the particulate carryover is examined. The combustor was fed coal and limestone with the coal to air ratio varying from 0.033 to 0.098 (ail lean) and the coal to limestone ratio varying from 0.06 to 0.36. Two cone angles were used and it is shown that the average particulate carryover of 2.5 grains/SCF is appreciably less than cylindrical fluidized bed combustors. In addition the carryover was correlated by multiple regression analysis to yield the dependence on bed depth and hence the collection efficiency, which was 20%. Finally, a comparison with a model indicated that the exhaust port may be below the transport disengaging height for most of the tests showing that further improvements could be achieved by increasing the freeboard height of the exhaust port above the bed.

M.E.P.

A79-51809 \* # Commercial phosphoric acid fuel cell system technology development. P. R. Prokopius, M. Warshay, S. N. Simons, and R. B. King (NASA, Lewis Research Center, Fuel Cell Projects Office, Cleveland, Ohio). In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings. Volume 1 (A79-51726 23-44) Washington, D.C., American Chemical Society, 1970, p. 538-543, 6 refs.

A review of the current commercial phosphoric acid fuel cell system technology development efforts is presented. In both the electric utility and on-site integrated energy system applications, reducing cost and increasing reliability are the technology drivers at this time. The long-standing barrier to the attainment of these goals, which manifests itrelf in a number of ways, has been materials. The differences in approach among the three major participants (United Technologies. Corporation (UTC), Westinghouse. Electric Corporation/Energy. Research Corporation (ERC), and Engelhard Industries) and their unique technological features, including electrodes, matrices, intercell cooling, bipolar/separator plates, electroliste management, fuel selection and system design philosophy are discussed. (Author)

A79-51837 \* # Recent advances in Redox flow cell storage systems. L. H. Thaller (NASA, Lewis Research Center, Cleveland, Onio), In: Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass. August 5-10, 1979, Proceedings. Volume 1 (A79-51726-23-44) Washington, D.C., American Chemical Society, 1979, p. 715-719, 8 rafs.

Attention is given to recent data pertaining to flow cell storage system-related features as well as the state of Redox membrane technology. In addition, the state of the technology as it relates to the two application areas of storage for photovoltaic/wind and distributed energy storage for electrical utility applications is addressed. Also covered are the cost and life advantages of Redox.

systems as well as a discussion of such cells as the open circuit voltage cell, the rebalance cell, and the trim cell. Finally, it is concluded that the main thrust of membrane development will be to reduce the interaction between the ciloro complex of iron in the ferric state since this is the major factor in membrane area resistivity.

M.E.P.

A79-53491 \* Evaluation of models to predict insolation on tilted surfaces. T. M. Klucher (NASA, Lewis Research Center, Cleveland, Ohio). Solar Energy, vol. 23, no. 2, 1979, p. 111-114. 8 tefs.

An empirical study was performed to evaluate the validity of various insolation models which employ either an isotropic or an anisotropic distribution approximation for sky light when predicting insolation on tilted surfaces. Data sets of measured hourly insolation values were obtained over a 6-month period using pyranometers which received diffuse and total solar radiation on a horizont. I plane and total radiation on surfaces tilted toward the equator at 37 degrees and 60 degrees angles above the horizon. Data on the horizontal surfaces were used in the insolation models to predict insolation on the tilted surface; comparisons of measured vs calculated insolation on the tilted surface were examined to test the validity of the sky light approximations. It was found that the Liu-Jordan isotropic distribution model provides a good fit to empirical data under overcast skies but underestimates the amount of solar radiation incident on tilted surfaces under clear and partly cloudy conditions. (Author)

N79-10625\*# United Technologies Corp., Windsor Locks, Conn. DESIGN, FABRICATION, AND TEST OF A COMPOSITE MATERIAL WIND TURBINE ROTOR BLADE Final Report D G Griffee, Jr., R E. Gustafson, and E. R. More Nov 1977 185 p. refs

(Contracts NAS3-19773, E(49-26)-1028) (NASA-CR-135389, DOE/NASA/9773-78/1, HSER-7383) Avail NTIS HC A09/MF A01, CSCL 10A

The aerodynamic design, structural design, fabrication, and structural testing is described for a 60 foot long filament wound, fiberglass/epoxy resin matrix wind turbine rotor blade for a 125 foot diameter, 100 kW wind energy conversion system. One blade was fabricated which met all aerodynamic shape requirements and was structurally capable of operating under all specified design conditions. The feasibility of filament winding large rotor blades was demonstrated.

# N79-10526\*# AiResearch Mfg Co. Phoenix, Ariz MINI-BRU/BIPS 1300 We DYNAMIC POWER CONVERSION SYSTEM DEVELOPMENT: EXECUTIVE SUMMARY Sep. 1978 25 p. refs

(Contract NAS3-18517)

(NASA-CR-159440, AiResearch-31-2937) Avail NTIS HC A02/MF A01 CSCL 10B

N79-11473\*# Rocket Research Corp., Redmond, Wash APPLICATIONS OF THERMAL ENERGY STORAGE TO PROCESS HEAT AND WASTE HEAT RECOVERY IN THE IRON AND STIEL INDUSTRY Final Report, Sep. 1977 Sep. 1978

Lincoln B Katter and Daniel J Peterson Oct 1978 136 p refs Sponsored by NASA

(Contracts EC-77-C-C1-5081: EC-77-A-31-1034)

(NASA-CR-159397, RRC-78-R-607, CONS/5081-1 NTIS HC A07/MF A01 CSCL 10A

The system identified operates from the primary arc furnace evacuation system as a heat source. Energy from the fume stream is stored as sensible energy in a solid medium (packed bed) A steam-driven turbine is arranged to generate power for peak shaving A parametric design approach is presented since the overall system design, at optimum payback is strongly dependent upon the nature of the electric pricing structure. The scope of the project was limited to consideration of available technology so that industry-wide application could be achieved by 1985. A search of the literature, coupled with interviews with representatives of major steel producers, served as the means whereby the techniques and technologies indicated for the specific site are extrapolated to the industry as a whole and o the 1985 time frame. The conclusion of the study is that by 1985, a national yearly savings of 19 million barrels of oil could be realized through recovery of waste heat from primary arc furnace fume gases on an industry-wide basis. Economic studies indicate that the proposed system has a plant payback time of approximately 5 years

N79 11476\* AiResearch Mfg Co. Torrance Calif DESIGN AND FABRICATION OF THE MINI BRAYTON RECUPERATOR (MBR) Final Report, Mar. 1974 - Jul. 1978

J J Killackey R Graves and G Mosinskis Apr 1978 99 p refs

(Contract NAS3 18029)

(NASA CR-159429, AiResearch 78-14972) Avail NTIS HC A05/MF A01 CSCL 10B

Development of a recuperator for a 2.0 kW closed Brayton space power system is described. The plate fin heat exchanger is fabricated entirely from Hastelloy X and is designed for 10 years continuous operation at 1000 K (1300 F) with a Xenon helium working fluid. Special design provisions assure uniform flow distribution crucial for meeting 0.975 temperature effectiveness Low-cycle fatigue, resulting from repeated startup and shut down cycles, was identified as the most critical structural design problem. It is predicted that the unit has a minimum fatigue life of 220 cycles. This is in excess of the BIPS requirement of 100 cycles. Heat transfer performance and thermal cycle testing with air, using a prototype unit, verified that all design objectives can be met Author

N79-12660°# Martin Marietta Corp., Denver, Colo. DEVELOPMENT OF SINGLE CELL PROTECTORS FOR SEALED SILVER-ZINC CELLS Fire Report

John W Lear, Richard L. Donovan, and Mathew S. Imarnura Nov 1978 68 p refs

(Contract NAS3-19432)

MCR-78-571) NASA-CR 159407 NTIS Avail HC A04/MF A01 CSCL 10C

Three design approaches to cell-level protection were developed, fabricated, and tested. These systems are referred to as the single-cell protector (SCP), multiplexed-cell protector (MCP). To evaluate the systems 18-cell battery packs without cell level control were subjected to cycle life test. A total of five batteries were subjected to simulate synchronous orbit cycling at 40% depth of discharge at 22C Batteries without cell-level protection failed between 345 and 255 cycles Cell failure in the cell level protected batteries occurred between 412 and 540 It was determined that the cell-level monitoring and protection is necessary to attain the long cycle life of a AgZn battery. The best method of providing control and protection of the AgZn cells depends on the specific application and capability of the user Author

N79-12563°# United Technologies Corp., East Hartford, Conn. Power Systems Div.

DEVELOPMENT OF ADVANCED FUEL CELL SYSTEM Final

Report, 25 Feb. - 31 Dec. 1976 B. Gitlow, A. F. Meyer, W. F. Bell, and R. E. Martin. 6 Jun. 1978 74 p refs

(Contract NAS3-19778)

FCF-0398) NTIS (NASA-CR-159443) Avail HC A04/MF A01 CSCL 10A

An experimental program was conducted continuing the development effort to improve the weight, life, and performance characteristics of hydrogen-oxygen alkaline fuel cel's for advanced power systems. These advanced technology cells operate with passive water removal which contributes to a lower system weight and extended operating life. Endurance evaluation of two single cells and two, two-cell plaques was continued. Three new test articles were fabricated and tested. A single cell completed 7036 hours of endurance testing. This cell incorporated a Fybex matrix. hybrid-frame. PPF anode, and a 90 Au/10 Pt cathode. This configuration was developed to extend cell life. Two cell plaques with dedicated flow fields and manifolds for all fluids did not exhibit the cell-to-cell electrolyte transfer that limited the operating life of earlier multicell plaques Author

N79-12564°# General Electric Co. Philadelphia. Pa

MINI-BRAYTON HEAT SOURCE ASSEMBLY DEVELOP MENT Final Report, 27 Jun. 1974 - 1 Oct. 1978

D Wein and W F Zimmerman 1 Nov 1978 306 p refs (Contract NAS3-18541)

NASA-CR-159447. Doc-78SDS4252)

HC A14/MF A01 CSCL 10A

The work accomplished on the Mini Brayton Heat Source Assembly program is summarized Required technologies to design, fabricate and assemble components for a high temperature Heat Source Assembly (HSA) which would generate and transfer the thermal energy for a spaceborne Brayton Isotope Power System (BIPS) were developed

#### N79-13490°# Naval Weapons Support Center, Crane, Ind. BLOCK 2 SOLAR CELL MODULE ENVIRONMENTAL TEST PROGRAM

Kevin L. Holloway Oct 1978 56 p refs. (NASA Order C-1892 D: Contract E(49-26)-1022) (NASA-CR-159393, DOE/NASA/1892-78/1.

WQEC/C-78-224) Avail NTIS HC A04/MF A01 CSCL 10A Environmental tests were performed of on 76 solar cell modules produced by four different manufacturers. The following tests were performed. (1) 28 day temperature and humidity. (2) rain and icing. (3) salt fog. (4) sand and dust. (5) vacuum/ steam/pressure, (6) fungus. (7) temperature/altitude, and (8) thermal shock Environmental testing of the solar cell modules produced cracked cells cracked encapsulant and encapsulant delaminations on various modules. In addition, there was some ...inor cell and frame corrosion.

N79-13496\*# General Electric Co., Santa Barbara, Calif. TEMPO

CONCEPTUAL DESIGN OF THERMAL ENERGY STORAGE SYSTEMS FOR NEAR TERM ELECTRIC UTILITY APPLICA-TIONS. VOLUME 1: SCREENING OF CONCEPTS

W Hausz, B J Berkowitz, and R C Hare Oct 1978 266 p Sponsored in part by Electric Power Research Inst 2 Vol (Contracts DEN-3-12, EC-77-A-31-1034)

NASA-CR-159411-Vol-1, GE78TMP-60-Vol-1

DOE/NASA/0012-78/1-Vol-1. EPRI-RP1092-1-Vol-1) Avail NTIS HC A12/MF A01 CSCL 10C

Over forty thermal energy storage (TES) concepts gathered from the literature and personal contacts were studied for their suitability for the electric utility application of storing energy off-peak discharge during peak hours. Twelve selections were derived from the concepts for screening, they used as storage media high temperature water (HTW) hot oil, molten salts, and packed beds of solids such as rock. HTW required pressuracontainment by prestressed cast iron or concrete vessels, or lined underground cavities. Both steam generation from storage and feedwater heating from storage were studied. Four choices were made for further study during the project. Economic comparison by electric utility standard cost practices, and near-term availability (low technical risk) were principal criteria but suitability for utility use, conservation potential, and environmental hazards were considered.

Author

N79-13497\*# General Electric Co. Santa Barbara, Calif.

CONCEPTUAL DESIGN OF THERMAL ENERGY STORAGE SYSTEMS FOR NEAR TERM ELECTRIC UTILITY APPLICA-TIONS. VOLUME 2: APPENDICES - SCREENING OF CONCEPTS

W Hausz, B J Berkowitz, and R. C. Hare Oct. 1978 144 p refs Sponsored in part by Electric Power Research Inst. 2 Vol.

(Contracts DEN-3-12; EC-77-A-31-1034)

(NASA-CR-159411-Vol-2; GE78TMP-60-Vol-2;

DOE/NASA/0012-78/1 Vol-2: EPRI-RP1082-1-Vol-2) Avail NTIS HC A07/MF A01 CSCL 10C

Volume 2 of this 2 volume report is represented. This volume contains three appendices: (1) bibliography and cross references; (2) taxonomy - proponents and sources; and (3) concept definitions.

# N79-16374\* # Energy Research Corp., Bethel, Corn. FABRICATION AND TESTING OF SILVER-HYDROGEN CELLS

M. G. Klein. Nov. 1978. 48 p. (Contract. NAS3-19780)

(NASA CR-159431) Avail NTIS HC A03/MF A01 CSCI

The development and life testing of single electrode and multi electrode stacks to optimize the individual components and characterize the performance of a silver hydrogen battery system are described A NASA-developed inorganic separator material was used as the main separator within the cells. Single electrode test cells were cycled at 75% of nominal capacity out through approximately 1,000 cycles in a number of cases where deterioration in performance was observed. This deterioration achears to be a decay in usable capacity of the silver electrode. but the exact mechanism is still unidentified. Twenty amperehour boilerplate test cells consisting of a stack of ten silver electrodes and twenty hydrogen electrodes were cycled also at 75% depth of discharge. The oldest stack achieved 522 stable cycles to the end of the program. Weight analysis of light-weight cells showed that 50 ampere-hour cells with improved components could be capable of as much as 40 watt hours per pound

ARH

# N79-16375\*# Energy Research Corp., Bethel, Conn. FABRICATION AND TESTING OF SILVER-HYDROGEN CELLS

Daniel J. DeBicarri and Atlen Charkey. Dec. 1978. 26 p. (Contract. NAS3-20805)

(NASA-CR:159490) Avail NTIS HC A03/MF A01 CSCL 10B

Silver electrodes containing various additives were fabricated and tested in single electrode cells in order to improve the electrochemical utilization of sintered silver cathodes in Ag-H2 aerospace batteries. A standard stack arrangement was used which featured a NASA-developed organic-inorganic separator All cells were cycled in a regime designed to remove 75% of the cells nominal capacity based on 3.3 gms/AHr Ag utilization. In cases where performance degradation was observed, the main feature mode appeared to be corrosion of either the expanded silver current collector or the connection between the silver electrode and the electrode tab. Promising silver electrodes from single electrode studies were used in the construction of 35 AHr Ag-H2 ce'ls Two such cells were constructed and installed in heavy walled pressure vessels for testing Based on the data obtained from all cells tasted during the program, four lightweight 35 AHr cells were fabricated During acceptance testing these cells yielded an average gravimetric energy density of 30 WHr/1b. A.R.H.

N79-17330\*# EIC, Inc., Newton, Mass.

FEASIBILITY STUDY FOR A SECONDARY Na/S BATTERY Final Report, 1 Oct. 1977 - 30 Sep. 1978

K. M. Abraham, R. Schiff, and S. B. Brummer Jan. 1979 65 p. rets.

(Contract NAS3-21028)

(NASA-CR-159469) Avail: NTIS HC A04/MF A01 CSCL 10C

The feasibility of a moderate temperature. Na battery was studied. This battery is to operate at a temperature in the range of 300-150. C. Two kinds of cathode were investigated: (1) a soluble S cathode consisting of a solution of Na2Sn in an organic solvent and (2) an insoluble S cathode consisting of a transition metal dichalcogenide in contact with a Na(+)ion conducting electrolyte. Four amide solvents, dimethyl acetamide, diethyl acetamide, N-methyl acetamide and acetamide, were investigated as possible solvents for the soluble S cathode. Results of stability and electrochemical studies using these solvents are presented. The dialkyl substituted amides were found to be superior. Although the alcohol 1.3-cyclohexanediol was found to be stable in the presence of Na2Sn at 130. C. its Na2Sn solutions did not appear to have suitable electrochemical properties.

N79-19448\*# RCA Labs., Princeton, N. J.
EPITAXIAL SOLAR-CELL FABRICATION, PHASE 2
Final Report, 11 Nov. 1974 - 10 Jun. 1977

R. V. Daiello, P. H. Robinson and H Kressel Nov. 1977 75 p refs

(Contract NA33-19401)

(NASA-CR-135350; PRRL-77 CR-45) Avail NTIS

HC A04/MF A01 CSCL 10A

Dichlorosilane (SiH2Cl2) was used as the silicon source material in all of the epitaxial growths. Both n/p/p(+) and p/n/n(+) structures were studied. Correlations were made between the measured profiles and the solar cell parameters. especially cell open-circuit voltage. It was found that in order to obtain consistently high open-circuit voltage, the epitaxial techniques used to grow the surface layer must be altered to obtain very abrupt doping profiles in the vicinity of the junction. With these techniques, it was possible to grow reproducibly bo p/n/n(+) and n/p/p(+) solar cell structures having open-circuit. voltages in the 610- to 630-mV range, with fill-factors in excess of 0.80 and AM-1 efficiencies of about 13%. Combinations and comparisons of epitaxial and diffused surface layers were also made. Using such surface layers, we found that the blue response of epitaxial cells could be improved, resulting in AM-1 short-circuit current densities of about 30 mA/cm sq. The best cells fabricated in this manner had AM-1 efficiency of 14.1%.

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M79-19451\*# Technical Marketing Associates, Inc., Concord, Mass

## MARKET DEFINITION STUDIES FOR PHOTOVOLTAIC HIGHWAY APPLICATIONS

Dec 1978 121 p

(Contracts DEN-3-40: DE-A101-79ET20485)

(NA SA - CR - 159477: DOE/NASA/0040-78/1) Avail: NTIS HC A06/MF A01 CSCL 10A

Prospects for solar electric power in applications related to highways within the continental United States are examined. Principal prospective users are found to be the highway departments of the various states. Economic analysis is employed to demonstrate that suitable applications can occur when powering apparatus such as signs, crossing signals, or instruments which consume less than 100 watts on the average, provided they are located at least one-half mile from existing utility power. Such applications are projected to occur two or three times per state per year. Attitudes of highway officials toward possible use of solar power are sampled and described. Although falling photovoltaic cell prices are expected to have little effect on sales potential here, methods for federal stimulation of this market are discussed.

N79-19454\* Comstock and Wescott, Inc., Cambridge, Mass. DEVELOPMENT OF A PHASE-CHANGE THERMAL STOR-AGE SYSTEM USING MODIFIED ANHYDROUS SODIUM HYDROXIDE FOR SOLAR ELECTRIC POWER GENERA-

Barry M. Cohen, Richard E. Rice, and Peter E. Rowny Dec. 1978 252 p refs Prepared for DOE

(Contracts NAS3-20615; EC-77-A-31-1034)

(NASA-CR-159465: DOE/NASA/0615-79/1) Avail: NTIS

HC A12/MF A01 CSCL 10A

A thermal storage system for use in solar power electricity generation was investigated analytically and experimentally. The thermal storage medium is principally anhydrous NaOH with 8% NaNO3 and 0.2% MnO2. Heat is charged into storage at 584 K and discharged from storage at 582 K by Therminol-66. Physical and thermophysical properties of the storage medium were measured. A mathematical simulation and computer program describing the operation of the system were developed. A 1/10 scale model of a system capable of storing and delivering 3.1 x 10 to the 6th power kJ of heat was designed, built, and tested. Tests included steady state charging, discharging, idling. and charge-discharge conditions simulating a solar daily cycle Experimental data and computer-predicted results are correlated. A reference design including cost estimates of the fuli-size system was developed

N79-20487°# West Virginia Univ., Morgantown.
SIMULATION OF FLUIDIZED BED COAL COMBUSTORS Final Report

Renga Rajan Feb 1979 215 p refs

(Grant NsG-3134)

(NASA-CR-159529) Avail NTIS HC A10/MF A01 CSCL

The many deficiencies of previous work on simulation of fluidized bed combustion (FBC) processes are presented. An attempt is made to reduce these deficiencies, and to formulate a comprehensive FBC model taking into account the following elements: (1) devolatilization of coal and the subsequent combustion of volatiles and residual char; (2) sulfur dioxide capture by limestone; (3) NOx release and reduction of NOx by char; (4) attrition and elutriation of char and limestone; (5) bubble hydrodynamics: (6) solids mixing: (7) heat transfer between gas and solid, and solid and heat exchange surfaces; and (8) freeboard

N79-20497\* Technical Report Services, Rocky River, Ohio EVALUATION OF URETHANE FOR FEASIBILITY OF USE IN WIND TURBINE BLADE DESIGN Final Report

Seymour Lieblein, Robert S. Ross (Concept Development Inst., Hudson, Ohio), and Demeter G. Fertis (Akron Univ.) Apr. 1979 156 p

(NASA Order C-7653, Contract E(49-26)-1028)

(NASA-CR-159530, DOE/NASA/7653-79/1, TRS-101) Avail NTIS HC AOB/MF AO1 CSCL 10B

A preliminary evaluation was conducted of the use of cast urethane as a possible material for low-cost blades for wind turbines. Specimen test data are presented for ultimate tensile strength, elastic modulus, flexural strain, creep, and fatigue properties of a number of urethane formulations. Data are also included for a large-scale urethane blade section composed of cast symmetrical half-profiles tested as a cantilever beam. Based on these results, an analysis was conducted of a full-scale blade design of cast urethare that meets the design specifications of the rotor blades for the NASA/DOE experimental 100-kW MOD-0 wind turbine. Because of the low value of elastic modulus for urethane (around 457 000 psi), the design loads would have to be carried by metal reinfo.cement. Considerations for further Author evaluation are noted

N79-21564\*# Honeywell, Inc., Minneapolis, Minn ACTIVE HEAT EXCHANGE SYSTEM DEVELOPMENT FOR LATENT HEAT THERMAL ENERGY STORAGE

R. T. LeFrois, G. R. Knowles, A. K. Mathur, and J. Budimir

Feb. 1979 122 p refs (Contracts DEN-3-38; EC-77-A-31-1034) (NASA-CR-159479; HI-78336; DOE/NASA/0038-79/1) Avail: NTIS HC A06/MF A01 CSCL 10A

Active heat exchange concepts for use with thermal energy storage systems in the temperature range of 250 C to 350 C. using the heat of fusion of molten salts for storing thermal energy are described. Salt mixtures that freeze and melt in appropriate ranges are identified and are evaluated for physicochemical, economic, corrosive and safety characteristics. Eight active heat exchange concepts for heat transfer during solidification are conceived and conceptual! designed for use with selected storage media. The concepts are analyzed for their scalability. maintenance, safety, technological development and costs. A model for estimating and scaling storage system costs is developed and is used for economic evaluation of salt mixtures and heat exchange concepts for a large scale application. The importance of comparing salts and heat exchange concepts on a total system cost basis, rather than the component cost basis alone, is pointed out. The heat exchange concepts were sized and compared for 6.5 MPa/281 C steam conditions and a 1000 MW(t) heat rate for six hours. A cost sensitivity analysis for other design conditions s also carried out.

N79-26506\*# General Electric Co., Philadelphia, Pa. Space

### AN INVESTIGATION OF THE ADHESIVE BONDING OF TEFLON SOLAR CELL COVERS

George J. Rayl 30 Apr. 1979 42 p refs

(Contract NAS3-21264)

(NASA-CR-159565. DOC-79SDS4218) NTIS

HC A03/MF A01 CSCL 10A

The concept of introducing organic agents into silicone resins to stabilize these materials against the ravages of ultraviolet radiation is presented. A screening of coating materials, cover materials and ultraviolet screening agents is described. Fabrication processes were developed for the application of thin 25 micrometer coatings to Teflon Temperature shock and temperature-humidity tests were conducted

N79-29603\*# Owens-Illinois, Inc., Toledo, Ohio ALTERNATE METHODS OF APPLYING DIFFLSANTS TO SILICON SOLAR CELLS Final Report, Jan. 1977 - Jan. 1978

Thomas W Brock and Marshall B Field (Pantek International, Lewistown, Pa.) Aug 1979 23 p refs

(Contract NAS3-20579)

(NASA-CR-159508) Avail NTIS HC A02/MF A01 CSCL 10A

Low-melting phosphate and borate glasses were screen printed on silicon wafers and heated to form n and p junctions Data on surface appearance, sheet resistance and junction depth are presented. Similar data are reported for vapor phase transport from sintered aluminum metaphosphate and boroncontaining glass-ceramic solid sources. Simultaneous diffusion of an N(+) layer with screen-printed glass and a p(+) layer with screen-printed Al alloy paste was attempted. No p(+) back surface field formation was achieved. Some good cells were produced but the heating in an endless-belt furnace caused a large scatter in sheet resistance and junction depth for three separate lots of wafers

N79-29604°# Energy Research Corp. Danbury. Conn TECHNOLOGY DEVELOPMENT FOR PHOSPHORIC ACID FUEL CELL POWERPLANT, PHASE 2 Quarterly Report

Larry Christner Mar 1979 50 p refs Prepared for NASA and DOF

(Contract DEN3-67)

NASA-CR-159572, DOE/NASA/0067-79/1) Avail NTIS HC A03/MF AU1 CSCL 10B

Component development has resulted in routine molding of 12 in by 17 in bipolar plates with 80 percent acceptance A 5 C per hour post-cure heating cycle for these plates was found to give blister free materials. Lowering the resin in a bipolar plate content from 32 percent to 22 percent decreases the resistivity more than 50 percent Evaluation of the corrosion resistance of Novolak and Resol resins at 185 C in phosphoric acid indicates a slow etch. Aresol modified phenolics, however, decompose rapidly. Estimates of scid loss by the use of analytical expressions known as Margule, van Laar, and Wilson equations were not satisfactory. Experimental evaluation of the P4010 vapor concentration of 103 wt percent acid at 191 C provided a value of 2 ppm. This value is based on a single experiment.

N79-30601\*# Boeing Engineering and Construction, Seattle, Wash

APPLICATIONS OF THERMAL ENERGY STORAGE TO PROCESS HEAT STORAGE AND RECOVERY IN THE PAPER AND PULP INDUSTRY Final Report, Sep. 1977 - May 1978

J. H. Carr, P. J. Hurley, and P. J. Martin Sep. 1978 244 p. refs Sponsored by NASA

(Contracts EC-77-A-31-1034; EC-77-C-01-5082)

(NASA-CR-159398: CONS-5082-1) NTIS HC A11/MF A01 CSCL 10C

Applications of Thermal Energy Storage (TES) in a paper and pulp mill power house were studied as one approach to the transfer of steam production from fossil fuel boilers to waste fuel of (hog fuel) briters. Data from specific mills were analyzed. and various TES concepts evaluated for application in the process steam supply system. Constant pressure and variable pressure steam accumulators were found to be the most attractive storage concepts for this application.

N79-31784\* # United Technologies Corp. South Windsor. Conn Power Systems Div

STRIP CELL TEST AND EVALUATION PROGRAM Report, 15 Jun. 1976 - 30 Apr. 1977

B. Gitlow, W. F. Beil, and R. E. Martin. 27 Oct. 1978, 76 p. refs

(Contract NAS3-20042)

power

NASA-CR-159652. FCR-0945) NTIS Avail HC A05/MF A01 CSCL 10B

The performance characteristics of alkaline fuel cells to be used for space power systems were tested. Endurance tests were conducted on the cells during energy conversion operations. A feature of the cells fabricated and tested was the capability to evaporate the product water formed during the energy conversion reaction directly to space vacuum. A fuel cell powerplant incoporating these cells does not require a condenser and a hydrogen recirculating pump water separato, to remove the product water. This simplified the fuel cell powerplant system. reduced the systems weight, and reduced the systems parasite AWH

#### N79-32646\* # Comsat Labs . Clarksburg. Md. OCESS IN SHALLOW JUNCTION SOLAR LIMITING CELLS

A Meulenberg and E Rittner in NASA Lewis Res. Center Solar Cell High Efficiency and Radiation Damage, 1979 Aug. 1979 p 35-36 Submitted for publication (For primary document see N79-32640 23-44)

Avail NTIS HC A13/MF A01 CSCL 10A

In extending the violet and nonreflective cell technology to lower resistivities, several processes limiting output power were encountered. The most important was the dark diffusion current due to recombination at the front grid contacts. After removal of this problem by reduction of the silicon metal contact area ( ) 0.14 percent of the total area), the electric field enhanced junction recombination current J sub r was the main limitation Alteration of the diffusion profile to reduce the junction field is shown to be an effective means of influencing J sub r. The remaining problems are the bulk recombination in the n+ layer and the surface recombination at the oxide-silicon interface, both of these problems are aggravated by band narrowing resulting from heavy doping in the diffused layer Experimental evidence for the main limitations is shown where increased diffusion temperature is seen to reduce both the influence of the front grid contacts and the junction electric field by increasing the junction depth. The potential for further significant improvement in efficiency appears to be high. J.M.S.

N79-32647°# Florida Univ., Gainesville. Dept. of Electrical Engineering

#### DESIGN OF HIGH EFFICIENCY HLE SOLAR CELLS FOR SPACE AND TERRESTRIAL APPLICATIONS

A. Neugroschel and F. A. Lindholm In NASA. Lewis Res. Center Solar Cell High Efficiency and Radiation Damage, 1979 Aug 1979 p 37-50 refs (For primary document see N79-32640 23-44)

(Grant NsG-3018)

Avail NTIS HC A13/MF A01 CSCL 10A

A first-order analysis of HLE cells is presented for both beginning-of-life and end-of-life conditions. Based on this analysis and on experimentally observed values for material parameters Design approaches for both space and terrestrial cells are presented. The approaches result in specification of doping levels. junction depths, and surface conditions. The proposed structures are projected to have both high V sub OC and high J s. b SC.

IMS

#### N79-32652\*# Solarex Corp., Rockville, Md. THIN CELLS FOR SPACE

G Storti, J Wohlgemuth, and C Wrigley In NASA Lewis Res Center Solar Cell High Efficiency and Radiation Damage. 1979 Aug 1979 p 87-95 refs (For primary document see N79-32640 23-44)

(Contracts NAS3-21250: JPL-954883)

Avail NTIS HC A13/MF A01 CSCL 10A

Research and pilot line production efforts directed towards the fabrication of high efficiency ultrathin silicon solar cells (50 micrometers) are reported. Conventional ultrathin cells with air-mass-zero (AMO) efficiencies exceeding 14% and coplanar back contact cells with AMO efficiencies up to 11.7% were developed. The primary mechanisms limiting efficiency were determined in both types of cells, and they are discussed within the context of further improving efficiency. Results of pilot line production of conventional ultrathin cells are also presented Average AMO efficiencies of 12% were radily achieved for 2000 RES cell production runs

#### N79-32654° # Optical Coating Lab . Inc . City of Industry. Calif SILICON SOLAR CELLS FOR SPACE USE: PRESENT PERFORMANCE AND TRENDS

P A lies, F 7. Ho, and S. Khemthong In NASA. Lewis Res. Center solar Cell High Efficiency and Radiation Damage, 1979 lug 1979 p 101-104 (For primary document see N79-32640

Avail NTIS HC A13/MF A01 CSCL 10A

A technology assessment of present performance levels and current fabrication methods and designs is presented. RES

N79-32662\* State Univ of New York at Albany the Study of Defects in Solids

#### HIGH-ENERGY ELECTRON-INDUCED DAMAGE PRODUC-TION AT ROOM TEMPERATURE IN ALUMINUM-DOPED SILICON

J W Corbett, L-J Cheng A Jaworowski, J P Karins, Y H Lee, L. Lindstroem (Foersvaret Forskningsanstalt, Stockholm, Sweden), P. M. Mooney (Vassar Coll.), G. Oehrlen, and K. L. Wang (GE Co., Schenectady, N Y.) In NASA Lewis Res Center Solar Cell High Efficiency and Radiation Damage, 1979 Aug 1979 p 185-196 refs (For primary document see N79-32640 23-44)

Avail NTIS HC A13/MF A01 CSCL 10A

DLTS and EPR measurements are reported on aluminumdoped silicon that was irradiated at room temperature with high-energy electrons. Comparisons are made to comparable experiment, on boron-doped silicon. Many of the same defects observed in boron-doped silicon are also observed in aluminumdoped silicon, but several others were not observed including the aluminum interstitlal and aluminum-associated defects

#### N79-33560° # General Electric Co. Schenectady. N. Y CONCEPTUAL DESIGN OF THERMAL ENERGY STORAGE SYSTEMS FOR NEAR TERM ELECTRIC UTILITY APPLICA-TIONS Final Report

E. W. Hall, W. Hausz, R. Anand, N. LaMarche, J. Oplinger, and M. Katzer, Jul. 1979, 359 p. refs. Sponsored by NASA. Prepared for DOF.

(Contracts DEN3-12; EC-77-A-31-1034-2; EPRI Proj. RP1082-1)

(NASA-CR-159577; GE79ET0101; DOE/NASA/0012-79/2) Avail NTIS HC A16/MF A01 CSCL 10B

Potential concepts for near term electric utility applications were identified. The most promising ones for conceptual design were evaluated for their economic feasibility and cost benefits. The screening process resulted in selecting two coal-fired and two nuclear plants for detailed conceptual design. The coal plants utilized peaking turbines and the nuclear plants varied the feedwater extraction to change power output. It was shown that the performance and costs of even the best of these systems could not compete in near term utility applications with cycling coal plants and typical gas turbines available for peaking power. Lower electricity costs, greater flexibility of operation, and other benefits can be provided by cycling coal plants for greater than 1500 hours of peaking or by gas turbines for less than 1500 hours if oil is available and its cost does not increase significantly.

RES

N79-33581\*# United Technologies Corp., South Windsor, Conn. Power Systems Div.

### ADVANCED TECHNOLOGY LIGHT WEIGHT FUEL CELL PROGRAM Final Report, 9 May 1977 - 16 Jun. 1978

R E Martin 16 Jun 1978 73 p refs (Contracts NAS3 20611, NAS3 20604) (NASA-CR-159653. FCR-1017) Avail NTIS HC A04/MF A01 CSCL 10A

A high performance hydrogen-oxygen alkaline fuel cell was investigated. Cell performance goals include. 0.9 volts at a current density of 1000 amperes per sq ft for 3000 hours at a cell temperature up to 300 F and reactant pressure up to 250 psia Subscale research cells were tested in the evaluation of five anode and five cathode catalyst configurations. Fuel cell matrices were fabricated from NASA supplied polybenzimidazole (PBI) powder. A cell edge frame and PBI matrix samples were corrosion tested in 42 wt% KOH at 250 F (121 C) A total of 13.828 hours of research cell testing at 250 F was completed in addition 494 hours of testing at temperatures up to 300 F and reactant pressures up to 250 psia with 27 hours of operation at or above 0.9 V/c at 1000 ASF was completed A supported platinum-on-carbon catalyst configuration demonstrated stable operation at high temperature. A new cell edge frame structure showed low weight loss during corrosion testing an indication of the material stability and long life potential

A79-10106 \* NaOH-based high temperature heat-of-fusion thermal entry storage device. B. M. Cohen and R. E. Rice (Comston) and Wescott, Inc., Cambridge, Mass.). In: Intersociety Energy Confersion Engineering Conference, 13th, San Diego, Calif., August 20-25, 1978, Proceedings, Volume 2. (A79-10001-01-44) Warrendale, Pa., Society of Automotive Engineers, Inc., 1978, p. 941-947. Pesearch supported by the U.S. Department of Energy; Contract No. NAS3-20615.

A material called Thermkeep, developed as a low-cost method for the storage of thermal energy for solar electric power generating systems is discussed. The storage device consists of an insulated cylinder containing Thermkeep in which coiled tubular heat exchangers are immersed. A one-tenth scale model of the design contains 25 heat-exchanger tubes and 1500 kg of Thermkeep. Its instrumentation includes thermocouples to measure internal Thermkeep temperatures, vessel surface, heated shroud surface, and pressure gauges to indicate heat-exchanger pressure drops. The

A79-17321 \* Phase change thermal storage for a solar total energy system. R. E. Rice and B. M. Cohen (Comstock and Wescott, Inc., Cambridge, Mass.). In: Sun: Mankind's future source of energy; Proceedings of the International Solar Energy Congress, New Delhi, India, January 16-21, 1978. Volume 1. (A79-17276 05-44) Elmsford, N.Y., Pergamon Press, Inc., 1978, p. 511-515. Research supported by the U.S. Department of Energy; Contract No. NAS3-20615.

An analytical and experimental program is being conducted on a one-tenth scale model of a high-temperature (584 K) phase-change thermal energy storage system for installation in a solar total energy test facility at Albuquerque, New Mexico, U.S.A. The thermal storage medium is anhydrous sodium hydroxide with 8% sodium nitrate. The program will produce data on the dynamic response of the system to repeated cycles of charging and discharging simulating those of the test facility. Data will be correlated with a mathematical model which will then be used in the design of the full-scale system. (Author)

A79-20825 \* Background and system description of the Mod 1 wind turbine generator. E. H. Ernst (General Electric Co., Valley Forge, Pa.). In Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 403-408. Contract No. NAS3-20058.

The Mod-1 wind turbine considered is a large utility-class machine, operating in the high wind regime, which has the potential for generation of utility grade power at costs competitive with other alternative energy sources. A Mod-1 wind turbine generator (WTG) description is presented, taking into account the two variable-pitch steel blades of the rotor, the drive train, power generation/control, the Nacelle structure, and the yaw drive. The major surface elements of the WTG are the ground enclosure, the back-up battery system, the step-up transformer, elements of the data system, cabling, area (ighting, and tower foundation. The final system weight (rotor, Nacelle, and tower) is expected to be about 650,000 pounds. The WTG will be capable of delivering 1800 kW to the utility grid in a wind-speed above 25 mph.

G.R.

A79-20826 \* Wind turbine generator application places unique demands on tower design and materials J. P. Kita (General Electric Co., Space Div., Valley Forge, Pa.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anahem, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 409-416. Contract No. NAS3-20058.

The most relevant contractual tower design requirements and goal for the Mod-1 tower are related to steel truss tower construction, cost-effective state-of-the-art design, a design life of 30 years, and maximum wind conditions of 120 mph at 30 feet elevation. The Mod-1 tower design approach was an iterative process. Static design loads were calculated and member sizes and overall geometry choses with the use of finite element computer techniques. Initial tower dynamic characteristics were then combined with the dynamic properties of the other wind turbine components, and a series of complex dynamic computer programs were run to establish a dynamic load set and then a second tower design.

G.R.

A79-20827 \* Fatigue impact on M: J-1 wind turbine design. C. V. Stahle, Jr. (General Electric Co., Space Div., Valley Forge, Pa.). In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79-20801 07-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 417-427. Contract No. NAS3-20058.

Fatigue is a key consideration in the design of a long-life Wind Turbine Generator (WTG) system. This paper discusses the fatigue aspects of the large Mod-1 horizontal-axis WTG design starting with the characterization of the environment and proceeding through the design. Major sources of fatigue loading are discussed and methods of limiting fatigue loading are described. NASTRAN finite element models are used to determine dynamic loading and internal cyclic stresses. Recent developments in determining the allowable fatigue stress—consistent with present construction codes are discussed relative to their application to WTG structural design. (Author)

A79-27400 \* # The application of hydraulics in the 2,000 kW wind turbine generator. S. Onufreiczuk (General Electric Co., Space Div., Valley Forge, Pa.). National Conference on Fluid Power and Power Transmission, Philadelphia, Pa., Nov. 7, 1978, Paper. 16 p. Contract No. NAS3-20058.

A 2000 kW turbine generator using hydraulic power in two of its control systems is being built under the management of NASA Lewis Research Center. The hydraulic systems providing the control torques and forces for the yaw and blade pitch control systems are discussed. The yaw-drive-system hydraulic supply provides the power for positioning the nacelle so that the rotary axis is kept in line with the direction of the prevailing wind, as well as pressure to the yaw and high speed shaft brakes. The pitch-change-mechanism hydraulic system provides the actuation to the pitch change mechanism and permits feathering of the blades during an emergency situation. It operates in conjunction with the overall windmill computer system, with the feather control permitting slewing control flow to pass from the servo valve to the actuators without restriction.

A.A.

A79-51780 \* Control and stabilization of the DOE/NASA Mod-1 two megawatt wind turbine generator. R. S. Barton (General Electric Co., King of Prussia, Pa.), C. E. J. Bowler, and R. J. Piwko (General Electric Co., Electric Utility Systems Engineering Dept., Schenectady, N.Y.). In Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5:10, 1979, Proceedings. Volume 1. (A79-51726 23-44) Washington, D.C., American Chemical Society, 1979, p. 325:330. 5 refs. Research supported by the U.S. Department of Energy, Contract No. NAS3:20058.

This paper describes the controls design, performance simulation process and specialized dynamic considerations for the DOE/NASA Mod 1 wind furbine generator (WTG). It shows controls, structural and utility interface considerations of the wind turbine generator and shows how a wind turbine generator can be integrated with a synchronous power system. Differences with respect to fossil or hydro generation and their implications are vital to long-term WTG reliability and availability and acceptance by utilities and consumers. The paper describes the control performance requirements to provide stable pitch and excitation control with drivetrain torsional dynamics, and the control of power swing stability and utility feeder voltage due to wind gusts.

(Author)

### 45 ENVIRONMENT POLLUTION

Includes air, noise, thermal and water pollution, environment monitoring; and contamination control.

N79-12586°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

APPLICATION OF ICN CHROMATOGRAPHY TO THE STUDY OF HYDROLYSIS OF SOME HALOGENATED HYDROCARBONS AT AMBIENT TEMPERATURES

Dumas A. Otterson 1978 24 p refs Presented at Symp. on Ion Chromatography, Sunnyvale, Calif , 21 Jun 1978 Sponsored by the Dionex Corp

(NASA-TM-79020, E-9817) Avail NTIS HC A02/MF A01 CSCL 07D

The application of ion chromatography to the study of very slow rates of hydrolysis of some halogenated hydrocarbons was investigated. The halide concentrations in the aqueous phase of mixtures of a carbonate buffer (pH = 10.3) and either chloroform (CHC13) or fluorotrichloromethane (CFC13) after aging for various lengths of time at room temperature, were determined by ion chromatography. Hydrolysis of CHC13 caused the C1(-) concentration to increase by about 1500 ppb per day. On the other hand neither the F(-) or C1(-) concentration in the CFC13 mixture increased by as much as 1 ppb per day. The magnitude of errors in the determination of halides prevented any firm conclusions regarding hydrolysis in this mixture. However, these results were used to show how ion chromatography could expedite identification of the hydrolyzing substance as well as investigations of  $\log d \cos \beta$  mechanisms.

Author

N79-15448°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPE VL0009

J. D. Holdeman, Thomas J. Dudzinski, Ted W. Nyland, and Marvin W. Tiefermann. Dec. 1978. 37 p. refs.

(NASA-TM-79058, E-9872, Rept-8) Avail: NTIS HC A03/MF A01 CSCL 04A

The GASP atmospheric trace constituent data cover atmospheric ozone, carbon monoxide, condensation nuclei, clouds, and related meteorological and flight information obtained during October 28-31, 1977. Reported herein are flight routes and dates, instrumentation, data processing procedures, and data tape specifications.

N79-15450\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPES VL0010 AND VL0012

J. D. Holdeman, Thomas J. Dudzinski, Marvin W. Tiefermann, and Ted W. Nyland. Jan. 1979, 77 p. refs.

(NASA-TM-79061, E-9874) Avail NTIS HC A05/MF A01 CSCL 13B

The GASP atmospheric trace constituent data currently available are considered. Included on tapes are in-situ measurements of atmospheric ozone, carbon monoxide, water vapor, and clouds, data from laboratory analysis of filters exposed in flight, and related flight and meteorological data. Measurements of ozone levels within the first class cabin of these aircraft are also reported. In addition to the GASP data, tropopause pressures obtained from time and space interpolation of NMC archived data for the dates of the flights are included. Reported herein are the flight routes and dates. Instrumentation, data processing procedures, data tape specifications, and analyses of the cabin ozone measurements.

G G

N79-17368\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ION CHROMATOGRAPHIC DETERMINATION OF SULFUR IN FUELS

Constance S Mizisin David E Kuivinen and Dumas A Otterson 1978 16 p. refs. Presented at the 2d Natl. Symp. on ion Chromatographic Analysis of Environ. Pollucants and other Analogous Compounds, Research Triangle Park, N. C., 11-13 Oct. 1978; sponsored by EPA

(NASA-TM-78971, E-9743) Avail NTIS HC A02/MF A01 CSCL 13B

The sulfur content of fuels was determined using an ion chromatograph to measure the sulfate produced by a modified Pari homb oxidation. Standard Reference Materials from the National Bureau of Standards, of approximately 0.2 + or - 0.004% sulfur, were analyzed resulting in a standard deviation no greater than 0.008. The ion chromatographic method can be applied to conventional fuels as well as shale-oil derived fuels. Other acid forming elements such as fluorine, chlorine and nitrogen could be determined at he same time, provided that these elements have reached a suitable ionic state during the oxidation of the fuel.

N79-17359\*# National Aeronautics and Space Administration. Lewis Research Center, C'eveland, Ohio.

NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPES V.0007 AND VL0008

J. D. Holdeman, Daniel J. Gauntner, Francis M. Humenik, and Daniel Briehl. Nov. 1977 58 p. refs.

(NASA-TM-73784, E-9348) Avail NTIS HC A04/MF A01 CSCL 13B

The Global Atmospheric Sampling Program (GASP) is obtaining measurements of atmospheric trace constituents in the upper troposphere and lower stratosphere using fully automated air sampling systems on board the NASA CV-990 research aircraft and four commerical B-747 aircraft in routine airline service In-situ measurements of atmospheric ozone and water vapor, data from laboratory analysis of filters exposed in flight, and related flight and meteorological data obtained from September 1976 through January 1977 are reported. These data are now available on GASP tapes VL0007 & VL0008 from the National Climatic Center, Asheville, North Carolina. In addition to the GASP data, tropopause pressure fields obtained from NMC archives for the dates of the GASP flights are included on the data tape. Flight routes and dates, instrumentation, data processing procedures, and data tape specifications are described.

N79-18479\*# National Aeronautics and Space Administration. Lewis Research Center Cleveland, Ohio.

CONL'ENSATION NUCLEI (AITKEN PARTICLE) MEASURE-MENT SYSTEM USED IN NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM

Ted W Nyland Feb 1979 28 p refs

(NASA-TP 1415, E 9816) Avail NTIS HC A03/MF A01 CSCL 13B

The condensation nuclei (Aitken particle) measuring system used in the NASA Global Atmospheric Sampling Program is described Included in the paper is a description of the condensation-nuclei monitor sensor, the pressurization system, and the Pollack-counter calibration system used to support the CN measurement. The monitor has a measurement range to 1000 CN/cm cubed and a noise level equivalent to 5 CN/cm cubed at flight altitudes between 6 and 13 km.

Author.

INDUSTRIAL POTENTIAL USES, AND PERFORMANCE OF SPUTTERED AND ION PLATED FILMS

Talivaldis Spalvins 1979 16 p refs Presented at the 22nd Ann Tech Conf of the Soc of Vacuum Coaters. New Orleans. 28-30 Mar 1979

(NASA-TM-79107, E-9932) Avail NTIS HC A02/MF A01 CSCL 20A

The sputtering and ion plating technology is reviewed in terms of their potential, uses and performance. It offers the greatest flexibility in coating preparation, since coatings can be tailored in any preferred chemical combination, and graded type interfaces (ceramic to metal seals) can be formed. Sputtered and ion plated film characteristics such as the degree of adherence, coherence and morphological growth which contribute to film performance and reliability are described and illustrated.

as used in practice. It is concluded that the potential future of sputtered and ion plated films for industrial applications will depend primarily upon greater comprehension of materials selection, possible elimination of restrictions for coating/substrate combinations and the awareness of utilizing the proper deposition parameters.

At hor

N79-20528° National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

EFFECTS OF AIR INJECTION ON A TURBOCHARGED TELEDYNE CONTINENTIAL MOTORS TSIO-360-C ENGINE Donald V. Cosgrove and Erwin E. Kempke 1979 37 p. refs. Presented at the Business Aircraft Meeting, Wichita, Kans.. 3-6 Apr. 1979; sponsored by the Soc. of Automotive Engr. (NASA-TM-79121; E-9955) Avail: NTIS HC A03/MF A01

A turbocharged fuel injected aircraft engine was operated over a range of lest conditions that included that EPA five-mode emissions cycle and fuel air ratio variations for individual modes while injecting air into the exhaust gas. Air injection resulted in a decrease of hydrocarbons and carbon mcnoxide while exceeding the maximum recommended turbine inlet temperature of 1650.5 at the full rich mixture of the engine. Leanout tests indicated that the EPA standards could be met through the combined use of fuel management and air injection.

Author

N79-22654\* # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio , OZONE MEASUREMENT SYSTEM FOR NASA GLOBAL AIR SAMPLING PROGRAM

Marvin W Tiefermann May 1979 21 p refs (NASA-TP-1451; E-9829) Avail: NTIS HC A02/MF A01 CSCL 138

The ozone measurement system used in the NASA Global Air Sampling Program is described. The system uses a commercially available ozone concentration monitor that was modified and repackaged so as to operate unattended in an aircraft environment. The modifications required for aircraft use are described along with the calibration techniques, the measurement of ozone loss in the sample lines and the operating procedures that were developed for use in the program. Based on calibrations with JPL's 5-meter ultraviolet photometer, all previously published GASP ozone data are biased high by 9 percent. A system error analysis showed that the total system measurement random error is from 3 to 8 percent of reading (depending on the oump diaphragm material) or 3-ppby, whichever are greater.

N79-31841\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

CARBON MONOXIDE MEASUREMENT IN THE GLOBAL ATMOSPHERIC SAMPLING PROGRAM

Thomas J Dudzinski Sep. 1979 26 p. refs (NASA-TP-1526, E-9972) Avail NTIS HC A03/MF A01 CSCL 38

The carbon monoxide measurement system used in the NASA Global Atmospheric Sampling Program (GASF) is described. The system used a modified version or a summercially available infrared absorption analyzer. The modifications increased the sensitivity of the analyzer to 1 ppmv full scale, with a immost strectability of 0.02 ppmv. Packaging was modified for automitic, unplicated operation in an aircraft environment. The GASP statem is described along with analyzer operation, calibration procedures, and measurement errors. Uncertainty of the CO measurement inversal 2-year period ranged from + or - 3 to + or - 13 persent of reading plus an error due to random fluctuation of the region signal + or - 3 to + or - 15 ppbv.

A79-15079 Pattern recognition methods and air pollution source identification. H. F. Leibecki and R. B. King (NASA, Lewis Research Center, Cleveland, Ohio). In: Joint Conference on Sensing of Environmental Pollutants, 4th, New Orleans, La., November 6-11, 1977, Proceedings. (A79-15023 04-45) Washington, D.C., American Chemical Society, 1978, p. 434-437. 9 refs.

Directional air samplers, used for resolving suspended particulate matter on the basis of time and wind direction were used to assess the feasibility of characterizing and identifying emission source types in urban multisource environments. Filters were evaluated for 16 elements and X-ray fluorescence methods yielded elemental concentrations for direction, day, and the interaction of direction and day. Large numbers of samples are necessary to compensate for large day-to-day variations caused by wind perturbations and/or source changes.

S.C.S.

A79-31332 \* # Measurements of carbon monoxide, condensation nuclei, and ozone on a B 7475P aircraft flight around the world. D. J. Gauntner, T. Nyland, M. Tiefermann, and T. Dudzinski (NASA, Lewis Research Center, Cleveland, Ohio). Geophysical Research Letters, vol. 6, Mar. 1979. p. 167-170, 10 refs.

Measurements of carbon monoxide, condensation nuclei, and ozone concentrations were obtained during a 54 hour polar flight around the world by an automated instrument package carried by a B-747SP commercial aircraft. These and other data were obtained as part of the NASA Global Atmospheric Sampling Program. All data exhibited longitudinal and hemispheric differences. Analysis of the data indicate increased concentrations of carbon monoxide and condensation nuclei at flight levels in the troposphere over tropical land masses. A background concentration for condensation nuclei was found to be 200 per cu cm for tropical tropospheric maritime air. (Author)

A79-38942 \* Experimental evidence of interhemispheric transport from airborne carbon monoxide measurements. R. E. Newell (MIT, Cambridge, Mass.) and D. J. Gauntner (NASA, Lewis Ricrearch Center, Cleveland, Ohio). Journal of Applied Meteorology, vol. 18, May 1979, p. 696-699. 9 refs. Research supported by the U.S. Department of Energy.

During the period 28-30 October 1977, a Pan American 747-SP aircraft flew around the world with an automated instrument package that included measurements of atmospheric CO made every 4 sec. The flight path extended from San Francisco, over the North Pole to London, south to Capetown, over the South Pole to Auckland, and back to San Francisco. The data collected show large changes with longitude, which are interpreted as direct evidence of interhemispheric mixing. Possible sources for CO are discussed. S.D.

A79-49494 \* Sulfate and nitrate mixing ratios in the vicinity of the tropopause. E. A. Lezberg, F. M. Humenik, and D. A. Otterson (NASA, Lewis Research Center, Cleveland, Ohio). Atmospheric Environment, vol. 13, no. 9, 1979, p. 1299-1304, 18 refs.

Measurements of suifate and nitrate in filter samples made during the Gooal Atmospheric Sampling Program (GASP) from aircraft Pring near the tropopause over a period of 28 months begin ag in early 1976 are presented. Sulfate and nitrate mixing mixios show a peak near or just above the tropopause during the winter-spring seasons. No peak is evident for sulfate during the summer-fall seasons. The sulfate mixing ratios show a constant average level in 1977-78 of 0.12 + or - 0.04 ppbm above the tropopause and 0.05 + or - 0.04 ppbm below the tropopause with higher levels in the spring. Nitrate levels are similar but exhibit greater variability. Correlations between sulfate and nitrate (r = 0.78) and between sulfate and nitrate, on ozone (r = 0.80, 0.78) suggest a predominately stratospheric source for these species.

N79-27716°# State Univ. of New York at Albany. Atmospheric

Sciences Research Center:
A SUMMARY OF RESEARCH ON THE NASA-GLOBAL
ATMOSPHERIC SAMPLING PROGRAM PERFORMED BY
THE ATMOSPHERIC SCIENCES PESEARCH CENTER Final

Phillip D. Falconer and Robert W. Pratt. Jun. 1979 59 p. refs. (Grant NsG-3138)

(NASA-CR-159614) Avail: NTIS HC A04/MF A01 CSCL 13B

The annual variations of ozone near the tropopause are derived from aircraft exhibit year-to-year differences which are not explicitly accounted for by the simple, classical ozone transport theory. Phenomena such as tropopause lifting, interannual variations in the rates of stratospheric-tropospheric exchange and meridional mixing, contribute differently to the distribution of czone in this altitude region. Ozone encounter climatologies have been represented by global maps which show the probabilities of exceeding ambient ozone levels of 200, 300, and 400 ppbV along flight routes during the year. Continuous ozone records obtained from the GASP system revealed the presence of gravity waves whose wavelength is of the order 20 km. The GASP data cannot, however, be utilized for the evaluation of horizontal fluxes of such quantities as ozone, sensible heat, and zonal momentum, the data are too sparsely and irregularly distributed for the computation of stable correlations. Multiple species data from the unique circumglobal flight of a Pair American airliner on 28-30 October 1977 are discussed with particular regard to the apparent interhemispheric differences in tropospheric species concentrations, variation between the Arctic and Antarctic stratospheres, to possible covariations between species, and to potential source regions for various constituents.

## **46** GEOPHYSICS

Includes aeronomy; upper and lower atmosphere stillings; ionospheric and magnetospheric physics, and geomagnetism.

For space radiation see 93 Space Radiation

A79-15068 An analysis of the first two years of GASP data. J. D. Holdeman (NASA, Lewis Research Center, Combustion and Pollution Research Branch, Cleveland, Ohio), G. D. Nastrom (Control Data Corp., Minneapolis, Minn.), and P. D. Falconer (New York, State University, Albany, N.Y.). In: Joint Conference on Sensing of Environmental Pollutants, 4th, New Orleans, La., November 6-11, 1977, Proceedings. (A79-15023 04 45) Washington, D.C., American Chemical Society, 1978, p. 313-317, 21 refs.

Distributions of mean ozone levels from the first two years of data from the NASA Global Atmospheric Sampling Program (GASP) show spatial and temporal variations in agreement with previous measurements. The standard deviations of these distributions reflect the large natural variability of ozone levels in the altitude range of the GASP measurements. Monthly mean levels of ozone below the tropopause show an annual cycle with a spring maximum which is believed to result from transport from the stratosphere. Correlations of ozone with independent meteorological parameters, and meteorological parameters obtained by the GASP systems show that this transport incurs primarily through cyclogenesis at mid-latitudes. The GASP water vapor data, analyzed with respect to the location of the tropopause, correlates well with the simultaneously obtained ozone and cloud data.

A79-44810 \* Ozone in the upper troposphere from Gasp measurements. G. D. Nastrom (Control Data Corp., Minneapolis, Minn.), Journal of Geophysical Research, vol. 84, July 20, 1979, p. 3683-3688, 24 refs. Contract No. NAS3-21249.

Several aspects of tropospheric ozone variations are examined by using ozone measurements made from commercial airliners (Gasp data). Through visual inspection of the autocorrelation function it is shown that the east-west variations of ozone have a predominant wavelength near 2400 km, while temperature and wind have predominant wavelengths near 3300 km. Distance-lagged correlation functions of ozone with temperature and wind show a definite periodicity with wavelengths near 2400 km. Attention is given to the tropical tropospheric ozone values above 100 parts per billion by volume, which appear to be associated with meridional transport from middle latitudes, and in some cases, relatively large tropical ozone values are coincident with clouds.

M.E.P.

## 47 METEOROLOGY AND CLIMATOLOGY

Includes weather forecasting and modification

N79-17418\* National Aeronautics and Space Administration Lewis Research Center, Claveland, Ohio

AIRCRAFT ICING

Porter J Perkins In Tenn Univ Space Inst Proc of the 2nd Ann Workshop on Meteorol and Environ Inputs to Aviation Systems Mar 1978 p 85-99 refs (For primary document see N79-17413 08-47)

Avail NTIS HC A12/MF A01 CSCL 04B

A representative of the NASA Lewis Research Center presented a discussion which concentrated on the meteorology of icing and its measurements. Other areas addressed were test facilities, ice protection systems, and the effects of ice on performance GY

N79-20672°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MODE 1 CRACK SURFACE DISPLACEMENTS FOR A ROUND COMPACT SPECIMEN SUBJECT TO A COUPLE AND FORCE

Bernard Gross 1979 13 p refs Presented at the 12th Nati Symp. on Fracture Mech., St. Louis, 21-23 May 1979; sponsored in part by the Am Soc for Testing and Mater (NASA-TM-79096, E-9920) Avail NTIS HC A02/MF A01

CSCL 04B Mode I displacement coefficients along the crack surface are presented for a radially cracked round compact specimen. treated as a plane elastostatic problem, subjected to two types of loading: a uniform tensile stress and a nominal bending stress distribution across the net section. By superposition the resultant displacement coefficient or the corresponding influence coefficient can be obtained for any practical load location. Load line displacements are presented for A/D ratios ranging from 0.40 to 0.95, where A is the crack langth measured from the crack mouth to the crack tip and D is the specimen diameter Through a linear extrapolation procedure crack mouth displacements are also obtained Experimental evidence shows that the results are valid over the range of A/D ratios analyzed for a practical pin loaded round compact specimen

N79-20621°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Chio

COMMERCIAL AIRCRAFT DERIVED HIGH RESOLUTION WIND AND TEMPERATURE DATA FROM THE TROPICS FOR FGGE: IMPLICATIONS FOR NASA

R. Steinberg In NASA. Coddard Space Flight Center 3d NASA Weather and Climate Program Sci. Rev. 1977. p. 265-270 (For primary document see N79-20575 11-47) Avail NTIS HC A14/MF A01 CSCL 04B

Two programs involving over 100 commercial aircraft were initiated to provide global high resolution in-situ windfield and temperature data during the FGGE The concepts developed for these programs could have important implications for both meteorology and aviation in the near term

A79 17180 . Ground-to-space optical power transfer, G. E. Meyers, C. L. Hayes, J. F. ScoHoo (Rockwell International Electronics Research Center, Anaheim, Calif J. and R. M. Stubbs (NASA, Lewis Research Center, Cleveland, Ohio). In Adaptive optical components. Proceedings of the Seminar, Washington, D.C., March 30, 31, 1978 (A79 17170 05 35) Bellingham, Wash, Society of Photo Optical Instrumentation Engineers, 1978, p. 108 117, 17 refs. Contract No NAS3 18937

Using laser radiation as the energy input to a rocket, it is possible to consider the transfer of large payloads economically between low initial orbits and higher energy orbits. In this paper we will discuss the results of an investigation to use a ground based High

Energy Laser (HEL) coupled to an adaptive antenna to transmit multi-megawatts of power to a satellite in low-earth orbit. Our investigation included diffraction effects, atmospheric transmission efficiency, adaptive compensation for atmospheric turbulence effects, including the servo bandwidth requirements for this correction, and the adaptive compensation for thermal blooming. For these evaluations we developed vertical profile models of atmospheric absorption, strength of optical turbulence (CN2), wind, temperature, and other parameters necessary to calculate system performance. Our atmospheric investigations were performed for CO2, 12C18O2 isotope, CO and DF wavelengths. For all of these considerations, output antenna locations of both sea level and mountain top (3.5 km above sea level) were used. Several adaptive system concepts were evaluated with a multiple source phased array concept being selected. This system uses an adaption technique of phase locking independent laser oscillators. When both system losses and atmospheric effects were assessed, the results predicted an overall power transfer efficiency of slightly greater than 50%. (Author)

### 48 OCEANOGRAPHY

Includes biological, dynamic and physical oceanography; and marine resources.

A79-51095 \* // A comparison of measured and calculated upwelling radiance over water as a function of sensor altitude. T. A. Coney and J. A. Salzman (NASA, Lewis Research Center, Cleveland, Ohio). University of Michigan, International Symposium on Remote Sensing of Environment, 13th, Ani: Arber, Mich., Apr. 23-27, 1379, Puper, 17 p. 7 rets.

The present paper compares remote sensing data measured over water at altitudes ranging from 30 m to 15.2 km to data calculated for corresponding altitudes using surface measurements and an atmospheric radiative transfer model. The data were acquired on June 22, 1978 in Lake Erie and it was found that suspended solids and chlorophyll concentrations were 0.59 + or -0.02 mg/liter and 2.42 + or -0.03 micro grain/liter respectively throughout the duration of the experiment. Calculated and measured nadia radiances for altitudes of 152 m and 12.5 km agree to within 16% and 14% respectively. It is noted that the model offered a poor simulation of the variation in measured radiance with look angle. Fins/ly, it is concluded that an accurate assessment of the source of error will require the inclusion in the analysis of the contributions made by the sea state and specular sky reflectance.

M.E.P.

## 53 BEHAVIORAL SCIENCES

Includes psychological factors; individual and group behavior, crew training and evaluation; and psychiatric research

N79-25753\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OVERALL LOUDNESS OF STEADY SOUNDS ACCORDING TO THEORY AND EXPERIMENT

Walton L. Howes Oct. 1979 150 p refs (NASA-RP-1001; E-8342) Avail: NTIS MF A01, HC SOD CSCL 05J

A mathematical theory for calculating the loudness of any steady sound from information on its spectrum is constructed from physical principles and psychological and physiological information on mammalian auditory systems. The theory involves filtering, channeling, squaring, half-wave rectification, and time average of the signal. The theory accounts for critical bands for loudness, audibility of sounds consisting of subliminal components, audible beats, periodicity pitch, and pitch of the residue. These and other pyschoacoustic phenomena are explained in terms of electrical activity in the peripheral nervous system. Simple approximations for loudness are derived from the more exact formulas Loudness predictions are compared with a wide variety of published loudness judgement data with considerable suc-Cess

## 54 MAN/SYSTEM TECHNOLOGY AND LIFE SUPPORT

Includes human engineering; biotechnology; and space suits and protective clothing.

A79-11544 \* # Digital enhancement of computerized axial tomograms. E. Roberts, Jr. (NASA, Lawis Research Center, Cleve land, Ohio). IEEE, NIH, and Stanford University, Annual Computers in Cardiology Conference, 5th, Stanford, Calif., Sept. 12-14, 1978, Pager, 5 p.

A systematic evaluation has been conducted of certain digital image enhancement techniques performed in image space. Three types of images have been used, computer generated phantoms, tomograms of a synthetic phantom, and axial tomograms of human anatomy containing images of lesions, artificially introduced into the tomograms. Several types of smoothing, sharpening, and histogram modification have been expiored. It has been concluded that the most useful enhancement techniques are a selective smoothing of singular picture elements, xombined with contrast manipulation. The most useful tool in applying these techniques is the gray-scale histogram. (Author)

# 60 COMPUTER OPERATIONS AND HARDWARE

Includes computer graphics and data processing
For components see 33 Electronics and Electrical
Engineering

N79-20752° | National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. LEWIS HYBRID COMPUTING SYSTEM, USERS MANUAL William M. Bruton and David S. Cwynar Apr. 1979 91 p (NASA-TM-79111; E-9938) Avail: NTIS Hic A05/MF A01 CSCL 098

The Lewis Research Center's Hybrid Simulation Lab contains a collection of analog, digital, and hybrid (combined analog and digital) computing equipment suitable for the dynamic simulation and analysis of complex systems. This report is intended as a guide to users of these computing systems. The report describes the available equipment' and outlines procedures for its use. Particular is given to the operation of the PACER 100 digital processor. System software to accomplish the usual digital tasks such as compiling, editing, etc. and Lewis-developed special purpose software are described.

N79-28881\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio INTRAOCULAR PRESSURE REDUCTION AND REGULA-

INTRAOCULAR PRESSURE REDUCTION AND REGULATION SYSTEM

Edward F Baehr, James E Burnett, Sanford F Felder, and William J. McGannon 1979 14 p. Presented at Symp on Glaucoma Surgery, Detroit, 17-18 May 1979

(NASA-TM-79187, E-038) Avail NTIS HC A02/MF A01 CSCL 06E

An intraocular pressure reduction and regulation system is described and data are presented covering performance in (1) reducing intraocular pressure to a preselected value, (2) maintaining a set minimum intraocular pressure, and (3) reducing the dynamic increases in intraocular pressure resulting from external loads applied to the eye.

Author

# 61 COMPUTER PROGRAMMING AND SOSTWARE

Includes computer programs, routines, and algorithms.

NT9-21798\* Mational Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INTERACTIVE DEBUG PROGRAM FOR EVALUATION AND MODIFICATION OF ASSEMBLY-LANGUAGE SOFTWARE Dale J. Arpasi Apr. 1979 82 p refs

(NASA-TP-1441; E-9219) Avail: NTIS HC A05/MF A01 CSCL 098

An assembly-language debug program written for the Honeywell HDC-601 and DDP-516/316 computers is described. Names and relative addressing to improve operator-machine interaction are used. Features include versatile display, on-line assembly, and improved program execution and analysis. The program is discussed from both a programmer's and an operator's standpoint. Functional diagrams are included to describe the program, and each command is illustrated.

S.E.S.

N79-23688\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

WETAIR: A COMPUTER CODE FOR CALCULATING THERMODYNAMIC AND TRANSPORT PROPERTIES OF AIR-WATER MIXTURES

Theodore E. Fessler May 1979 16 p refs (NASA-TP-1466; E-9801) Avail. NTIS HC A02/MF A01 CSCL 09B

A computer program subroutine. WETAIR was developf to calculate the thermodynamic and transport properties of air water mixtures. It determines the thermodynamic state from assigned values of temperature and density, pressure and density, temperature and pressure pressure and entropy, or pressure and enthalpy. The WETAIR calculates the properties of dry air and water (steam) by interpolating to obtain values from property tables. Then it uses simple mixing laws to calculate the properties of air water mixtures. Properties of mixtures with water contents below 40 percent (by mass) can be calculated at temperatures from 273.2 to 1497. K and pressures to 450 MN/sq m. Dry air properties can be calculated at temperatures as low as 150 K. Water properties can be calculated at temperatures to 1747. C and pressures to 100 MN/sq m. The WETAIR is available in bc a SETRAN and FORTRAN.

N79-29832\*# Lockheed Missiles and Space Co., Huntsville, Ala Research and Engineering Center

CELFE: COUPLED EULERIAN-LAGRANGIAN FINITE ELEMENT PROGRAM FOR HIGH VELOCITY IMPACT. PART 1: THEORY AND FORMULATION Final Report, Jun. 1975 - Sep. 1977

C H Lee Jan 1978 168 p (Contract NAS3 18908)

to

(NASA-CR-159395, LMSC-HREC-TR-D497204-Pt-1) Avail NTIG HC A08/MF A01 CSCL 09B

A 3-D finite element program capable of simulating the dynamic behavior in the vicinity of the impact point, together with predicting the dynamic response in the remaining part of the structural component subjected to high velocity impact is discussed. The finite algorithm is formulated in a general moving coordinate system in the vicinity of the impact point contained by a moving failure front, the relative velocity of the coordinate system will approach the material particle velocity The dynamic behavior inside the region is described by Eulerian formulation based on a hydroelasto-viscoplastic model. The failure front which can be regarded as the boundary of the impact zone is described by a transition layer. The layer changes the representation from the Eulerian mode to the Lagrangian mode outside the failure front by varying the relative velocity of the coordinate system to zero. The dynamic response in the remaining part of the structure described by the Lagrangian formulation is treated using advanced structural analysis. An interfacing algorithm for coupling CELFE with NASTRAN is constructed to provide computational capabilities for large structures

N79-29833\* Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center.

CELFE: COUPLED EULERIAN-LAGRANGIAN FINITE ELEMENT PROGRAM FOR HIGH VELOCITY IMPACT. PART 2: PROGRAM USER'S MANUAL Final Report, Jun. 1975 - Sep. 1977

C. H. Lee Jan. 1978 270 p (Contract NAS3-18908)

(NASA-CR-159396; LMSC-HREC-TR-D497204-Pt-2) Avail. NTIS HC A12/MF A01 CSCL 09B

The CELFE computer program and user's manual, together with the execution of the CELFE/NASTRAN system, are described. The execution procedure and the transfer of data between the CELFE and NASTRAN programs are controlled through the use of DATA files in the Univac 1100 system. Five data files are used to control the runstream and data transfer, and three files are used to hold the programs. These files are contained on a single tape. Changes in NASTRAN routines required by the present analysis are also discussed in this report. All the program listings, except the last two files (where the absolute and relocatable elements are stored), are included in the appendixes.

N79-33881\*# Boeing Computer Services, Inc., Seattle, Wash. Energy Technology Applications Div

AN EXPANDED SYSTEM SIMULATION MODEL FOR SOLAR ENERGY STORAGE (TECHNICAL REPORT), VOLUME 1 Final Report

A W Warren Aug 1979 107 p refs 2 Vol. (Contracts DEN3-42; EX-76-A-31-1026) (NASA-CR-159601, DOE/NASA/0042-79/1-Vol-1; BCS-40159-1) Avail NTIS HC A06/MF A01 CSCL 09B

The simulation model for wind energy storage (SIMWEST) program now includes wind and/or photovoltaic systems utilizing any combination of five types of storage (pumped hydro, battery, therinal, flywheel and pneumatic) and is available for the UNIVAC 1100 series and the CDC 6000 series computers. The level of detail is consistent with a role of evaluating the economic feasibility as well as the general performance of wind and/or photovoltaic energy systems. The software package consists of two basic programs and a library of system, environmental, and load components. The first program is a precompiler which generates computer models (in FORTRAN) of complex wind and/or photovoltaic source/storage/application systems, from user specifications using the respective library components. The second program provides the techno-economic system analysis with the respective I/O, the integration of system dynamics. and the iteration for conveyance of variables.

N79-33882\*# Boeing Computer Services, Inc., Seattle, Wash Energy Technology Applications Div.

AN EXPANDED SYSTEM SIMULATION MODEL FOR SOLAR ENERGY STORAGE (UNIVAC OPERATION MANUAL REVISIONS), VOLUME 2 Final Report

A W Warren Aug 1979 198 p refs 2 Vol (Contracts DEN3-42; EX-76-A-31-1026) (NASA-CR-159602, DOE/NASA/0042-79/2-Vol-2, BCS-40180-2-Rev) Avail NTIS HC A09/MF A01 098

Additions or revisions of components of the SINWEST program are provided for insertion into the manual used with the UNIVAC 1100 series computer ARH

 $\mbox{N79-33883*}\#$  Boeing Computer Services, Inc., Seattle, Wash Energy Technology Applications Div

SIMWEST: A SIMULATION MODEL FOR WIND AND PHOTOVOLTAIC ENERGY STORAGE SYSTEMS (CDC USER'S MANUAL), VOLUME 1 Final Report

A. W Warren and A W Esinger Aug 1979 486 p. refs

(Contracts DEN3-42, EX-76-A-31-1026)

(NASA-CR-159607, DOE/NASA/0042-79/3-Vol-1

BCS-40262-1) Avail NTIS HC A21/MF A01 CSCL 09B

Procedures are given for using the SIMWEST program on CDC 6000 series computers. This expanded software package includes wind and/or photovoltaic systems utilizing any combination of five types of storage (pumped hydro, battery, thermal, flywheel, and pneumatic). A R H

N79-33884\* Boeing Computer Services. Inc., Seattle. Wash. Energy Technology Applications Div.

SIMWEST: A SIMULATION MODEL FOR WIND AND PHOTOVOLTAIC ENERGY STORAGE SYSTEMS (CDC PROGRAM DESCRIPTIONS), VOLUME 2 Final Report A. W. Warren, R. W. Edsinger. and J. D. Burroughs Aug. 1979 247 p 2 Vol.

(Contracts DEN3-42; EX-76-A-31-1026)
(NASA-CR-159608; DOE/NASA/0042-79, \*-Vol-2; BCS-40262-2) Avail. NTIS HC A11/MF A01 CSCL 09B The computer programs for the CDC version of SIMWEST (1979 revision) are described. Macro flow charts and source code listings for each major program entity are presented A.R.H.

### 64 NUMERICAL ANALYSIS

Includes iteration, difference equations, and numerical approximation.

N79-28970\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

NUMBERS OF CENTER POINTS APPROPRIATE TO BLOCKED RESPONSE SURFACE EXPERIMENTS

Arthur G. Holms. 1979. 34 p. refs. Presented at 139th Ann. Meeting of the Am. Statistical Assoc., Washington, D. C. 13-16, Aug. 1979.

(NASA-TM-79201, E-082) Avail NTIS HC A03/MF A01 CSCL 12A

Tables are given for the numbers of center points to be used with blocked sequential designs of composite response surface experiments as used in empirical optimum seeking. The star point radii for exact orthogonal blocking is presented. The center point options varied from a lower limit of one to an upper limit equal to the numbers proposed by Box and Hunter for approximate rotatability and uniform variance, and exact orthogonal blocking. Some operating characteristics of the proposed options are described.

A79-40494 \* Acceleration of linear and logarithmic convergence. D. A. Smith and W. F. Ford (NASA, Lewis Research Center, Computer Services Div., Cleveland, Ohio). SIAM Journal on Numerical Analysis, vol. 16, Apr. 1979, p. 223-240. 39 refs. Grant No. NsG-3160

Eleven different methods for accelerating convergence of sequences and series have been tested and compared on a wide range of test problems, including both linearly and logarithmically convergent series, monotone and alternating series. All but one of these methods are already in the literature, and they include both linear and nonlinear methods. The only methods found to accelerate convergence across the board were the u and v transforms of Levin and the theta algorithm of Brezinski. The paper gives detailed comparisons of all the tested methods on the basis of number of correct digits in the answer as a function of number of terms of the series used. A theorem of Germain-Bonne states that methods of a certain form which are exact on geometric series will accelerate linear convergence. The theorem applies to theta sub 2, and we have extended it to apply to Levin's transforms. No corresponding theorem is known for logarithmic convergence, but u, v, and theta are exact on certain large classes of logarithmic series, and all tested methods lacking this property failed to accelerate some logarithmically convergent series. (Author)

## 65 STATISTICS AND PROBABILITY

Includes data sampling and smoothing. Monte Carlo method, and stochastic processes

N79-23736\* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

MAXIMUM LIKELIHOOD ESTIMATION FOR LIFE DISTRI-BUTIONS WITH COMPETING FAILURE MODES

Steven M. Sidik 1979 41 p refs to presented at the Ann Meeting of the Am. Statist. Assoc., Washington, D. C., 13-16 Aug 1979

(NASA-TM-79126, E-9962) Avail NTIS HC A03/MF A01 CSCL 14D

Systems which are placed on test at time zero, function for a period and die at some random time were studied Failure may be due to one of several causes or modes. The parameters of the life distribution may depend upon the levels of various stress variables the item is subject to. Maximum likelihood estimation methods are discussed. Specific methods are reported for the smallest extreme-value distributions of life Monte-Carlo results indicate the methods to be promising. Under appropriate conditions, the location parameters are nearly unbaised, the scale parameter is slight biased, and the asymptotic covariances are rapidly approached SES

A79-49528 \* # Maximum likelihood estimation for life distributions with competing failure modes. S. M. Sidik (NASA, Lewis Research Center, Cleveland, Ohio). American Statistical Association, Annual Meeting, 39th, Washington, D.C., Aug. 13-16, 1979, Paper. 37 p. 13 refs.

The general model for the competing failure modes assuming that location parameters for each mode are expressible as linear functions of the stress variables and the failure modes act independently is presented. The general form of the likelihood function and the likelihood equations are derived for the extreme value distributions, and solving these equations using nonlinear least squares techniques provides an estimate of the asymptotic covariance matrix of the estimators. Monte-Carlo results indicate that, under appropriate conditions, the location parameters are nearly unbiased, the scale palameter is slightly biased, and the asymptotic covariances are rapidly approached.

A79-49529 \* # Numbers of center points appropriate to blocked response surface experiments. A G Holms (NASA, Lewis Research Center, Cleveland, Ohio), American Statistical Association, Annual Meeting, 139th, Washington, D.C., Aug. 13-16, 1979, Paper. 33 p. 16 refs.

Tables are given for the numbers of center points to be used with blocked sequential designs of composite response surface experiments as used in empirical optimum seeking. The tables also give the star point radii for exact orthogonal blocking. The center point options vary from a lower limit of one to an upper limit equal to the numbers proposed by Box and Hunter for approximate rotatability and uniform variance, and exact orthogonal blocking Some operating characteristics of the proposed options are described (Author)

### 66 SYSTEMS ANALYSIS

Includes mathematical modeling; network analysis; and operations research.

N79-29938\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTERIZED SYSTEMS ANALYSIS AND OPTIMIZA-TION OF AIRCRAFT ENGINE PERFORMANCE, WEIGHT, AND LIFE CYCLE COSTS

Laurence H Fishbach 1979 22 p refs Presented at Flight Mech Panel Symp on the Use of Computers as a Design Tool, Munich, 3-6 Sep 1979, sponsored by AGARD

(NASA TM-79221, E-112) Avail NTIS HC A02/MF A01 CSCL 12B

The computational techniques utilized to determine the optimum propulsion systems for future aircraft applications and to identify system tradeoffs and technology requirements are described. The characteristics and use of the following computer codes are discussed (1) NNEP - a very general cycle analysis code that can assemble an arbitrary matrix fans, turbines, ducts, shafts, etc. into a complete gas turbine engine and compute on- and off-design thermodynamic performance, (2) WATE - a preliminary design procedure for calculating engine weight using the component characteristics determined by NNEP. (3) POD DRG - a table look-up program to calculate wave and friction drag of nacelles; (4) LIFCYC - a computer code developed to calculate life cycle costs of engines based on the output from WATE, and (b) INSTAL - a computer code developed to calculate installation effects, inlet performance and inlet weight. Examples are given to illustrate how these computer techniques can be applied to analyze and optimize propulsion system fuel consumption, weight, and cost for representative types of aircraft and missions

## 70 PHYSICS (GENERAL)

For geophysics see 46 Geophysics For astrophysics see 90 Astrophysics. For solar physics see 92 Solar physics

A79-50938 \* Effects of bulk and surface conductivity on the potential developed by dielectrics exposed to electron beams. M. Rotenberg (Systems, Science and Software; California, University, La Jolla, Calif.), M. J. Mandell, and D. E. Parks (Systems, Science and Software, La Jolla, Calif.). *Journal of Applied Physics*, vol. 50, Sept. 1979, p. 5823-5825, 7 refs. Contract No. NAS3-21050.

The charging and discharging of a dielectric material which has bulk and surface conductivities is discussed. Two model proelems are solved. In the first problem, a semi-infinite dielectric plane, attached to an infinite grounded conducting substrate and exposed to a monoenergetic electron beam, is analyzed. Bulk and surface conductivities and secondary emission characteristics are taken into account as parameters. In the second problem the dielectric is charged but the electron beam is shut off so only the bulk and surface conductivities enter the calculation. The principal mostly of the fatter calculation is to show that steep tangential gradients develop in the presence of a surface conductivity during decay, and that for asymptotic times the temporal behavior, for a fixed position, is proportional to the square root of t rather than exponential, as expected in the presence of a bulk conductivity.

(Author)

### 71 ACOUSTICS

Includes sound generation, transmission and attenua-

For noise pollution see 45 Environment Pollution

N79-14871\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. SOUND-SUPPRESSING STRUCTURE WITH THERMAL RELIEF Patent

Dudley O. Nash (GE, Cincinnati) and Joseph Holowach, inventors (to NASA) Issued 15 Aug. 1978 5 p Filed 2 Jul. 1976 Sponsored by NASA

(NASA-Case-LFW-12658-1; US-Patent-4,106,587;

US-Patent-Appl-SN-702115; US-Patent-Class-181-213;

US-Patent-Class-181-222; US-Patent-Class-181-190;

US-Petent-Class-181-293) Avail: US Petent and Trademark Office CSCL 20A

Sound-suppressing structure comprising stacked acoustic panels wherein the inner high frequency panel is mounted for thermal expansion with respect to the outer low frequency panel is discussed. Slip joints eliminate the potential for thermal stresses, and a thermal expansion gap between the panels provides for additional relative thermal growth while ruducing heat convection into the low frequency panel.

Official Gazette of the U.S. Patent and Trademark Office

N79-15757\*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

FEASIBILITY OF WING SHIELDING OF THE AIRPLANE INTERIOR FROM THE SHOCK NOISE GENERATED BY SUPERSONIC TIP SPEED PROPELLERS

James H Dittmar Dec 1978 25 p refs (NASA-TM-79042, E-9845) Avail NTIS HC A02/MF A01 CSCL 20A

A high tip speed turboprop is being considered as a future energy conservative airplane. The high tip speed of the propeller, combined with the speed of the airplane, results in supersonic relative flow on the propeller tips. These supersonic blade sections could generate noise that is a cabin environment problem. The feasibility of using wing shielding to lessen the impact of this supersonic propeller noise was investigated. An analytical model is chosen which considers that shock waves are associated with the propeller tip flow and indicates how they would be prevented from impinging on the airplane fuselage. An example calculation is performed where a swept wing is used to shield the fuselage from significant portions of the propeller shock waves.

N79-15758°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

TONE NOISE OF THREE SUPERSONIC HELICAL TIP SPEED PROPELLERS IN A WIND TUNNEL AT 0.8 MACH NUMBER

James H. Dittmar. Bernard J. Blaha, and Robert J. Jeracki. Dec. 1978, 22 p. refs.

(NASA-TM-79046, E-9854) Avail NTIS HC A02/MF A01 CSCL 20A

Three supersonic helical tip speed propellers were tested in the NASA Lewis 8- by 6-foot wind tunnel. Noise data were obtained while these propellers were operating at a simulated cruse condition. The walls of this tunnel were not acoustically treated and therefore this was not an ideal location for taking noise data, but it was thought that the differences in noise among the three propellers would be meaningful. The straight bladed propeller which did not incorporate sweep was the noisiest with the aerodynamically swept propeller only slightly quieter. However, the acoustically swept propeller was significantly quieter than the straight propeller, thereby indicating the ment of this design technique.

Author

N79-15759\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPTIMIZED MULTISECTIONED ACOUSTIC LINERS

(NASA-TM-79028; E-9823) Avail NTIS HC A02/MF A01 CSCL 20A

New calculations show that segmenting is most efficient at high frequencies with relatively long duct lengths where the attenuation is low for both uniform and segmented liners. Statistical considerations indicate little advantage in using optimized liners with more than two segments while the bandwidth of an optimized two-segment liner is shown to be nearly equal to that of a uniform liner. Multielement liner calculations show a large degradation in performance due to changes ii: assumed input modal structure. Computer programs are used to generate theoretical attenuations for a number of liner configurations for liners in a rectangular duct with no mean flow. Overall, the use of optimized multisectioned liners fails to offer sufficient advantage over a uniform liner to warrant their use except in low frequency single mode application.

N79-15756\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MODAL PROPAGATION ANGLES IN A CYLINDRICAL DUCT WITH FLOW AND THEIR RELATION TO SOUND RADIA-TION

Edward J Rice, Marcus F, Heidmann, and Thomas G. Sofrin (Pratt and Whitney Aircraft, East Hartford, Conn.) Jan. 1979 12 p. refs. Presented at 17th Aerospace Sci. Meeting, New Orleans, La. 15-17 Jan. 1979, sponsored by AIAA (NASA-TM-79030, E-9826). Avail: NTIS. HC A02/MF A01 CSCL 20A

The main emphasis is upon the propagation angle with respect to the duct axis and its relation to the far-field acoustic radiation pattern. When the steady flow Mach number is accounted for in the duct, the propagation angle in the duct is shown to be coincident with the angle of the principal lobe of far-field radiation obtained using the Wiener-Hopf technique Different Mach numbers are allowed within the duct and in the external field. For static tests with a steady flow in an inlet but with no external Mach number the far-field radiation pattern is shifted considerably toward the inlet axis when compared to zero Mach number radiation theory. As the external Mach number is increased the noise radiation pattern is shifted away from the inlet axis The theory is developed using approximations for sound propagation in circular ducts. An exact analysis using Hankel function solutions for the zero Mach number case is given to provide a check of the simpler approximate theory Author

N79-16644\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

THREE-DIMENSIONAL FINITE ELEMENT ELASTIC ANALYSIS OF A THERMALLY CYCLED SINGLE-EDGE WEDGE GEOMETRY SPECIMEN

Peter T Bizon, Richard J Hill (AFAFL), Bruce P Guilliams, Sandra K. Drake (AFAPL), and Jeffrey L Kladden (AFAPL). Jan. 1979-53 p. refs.

(NASA-TM-79026, E-9861) Avail NTIS HC A04/MF A01 CSCL 20A

An clastic stress analysis was performed on a wedge specimen (prismatic bar with single-wedge cross section) subjected to thernal cycles in fluidzed beds. Seven different combinations consisting of three alloys (NASA TAZ-8A, 316 stainless steel, and A-286) and four therinal cycling conditions were analyzed. The analyses were performed as a joint effort of two laboratories using different models and computer programs (NASTRAN and ISO3DQ). Stress, strain, and temperature results are presented.

Author

N79-16645\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

# FULL SCALE ENGINE TESTS OF BULK ABSORBER ACOUSTIC INLET TREATMENT

L J. Heidelberg and L. Homyak. 1979. 16 p. refs. Presented at the 5th Aeroacoustics Conf., Seattle, 12-14 Mar. 1979; sponsored by AIAA.

(NASA TM 79079, E-9899) Avail NTIS HC A02/MF A01 CSCL 20A

Three different densities of Keviar bulk absorber fan inlet treatment were tested un a YF 102 turbofan engine. This bulk absorber material may have potential for flight application. Farfield noise measurements were made and the attenuation properties of the three treatment densities were compared. In addition, the best bulk treatment was compared to the best single degree of freedom, SDOF (honeycomb and perforal dicover sheet) treatment from another investigation. Although the density was varied over a large range (3 to 1) the effect on attenuation was small. The highest density treatment. 11.8 lb/cubic ft. had a somewhat broader attenuation bandwidth. The comparison of the best bulk and SDOF treatments showed the bulk to have a much greater attenuation bandwidth. At the design frequency both types of treatment had almost equal performance.

N79-16646\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

# MODAL PROPAGATION ANGLES IN DUCTS WITH SOFT WALLS AND THEIR CONNECTION WITH SUPPRESSOR PERFORMANCE

Edward J Rice 1979 16 p refs Presented at the 5th Aeroacoustics Conf. Seattle, 12-14 Mar 1979, sponsored by AIAA

(NASA-TM 79081, E-9902) Avail NTIS HC A02/MF A01 CSCL 20A

The angles of propagation of the wave fronts associated with duct modes are derived for a cylindrical duct with soft walls (acoustic suppressors) and a uniform steady flow. The angle of propagation with respect to the radial coordinate langle of incidence on the wall) is shown to be a better correlating parameter for the optimum wall impedance of spinning modes than the previously used mode cutoff ratio. Both the angle of incidence upon the duct wall and the propagation angle with respect to the duct axis are required to describe the attenuation of a propagating mode. Using the modal propagation angles a geometric acoustics approach to suppressor acoustic performance was developed Results from this approximate method were compared to exact modal propagation calculations to check the accuracy of the approximate method. The results are favorable except in the immediate vicinity of the modal optimum impedance where the approximate method yields about one half of the exact maximum attenuation

N79 16647\*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

## EFFECTS OF INFLOW DISTORTION PROFILES ON FAN TONE NOISE CALCULATED USING A 3-D THEORY

Hiroshi Kobayashi and John F. Groeneweg. 1979. 18 p. refs. Presented at the 5th Aeroacoustics Cont. Seattle. Wash. 12.14 Mar. 1979. sponsored by AIAA.

(NASA TM 79082 E 9904) Avail NTIS HC A02/MF A01 CSCL 20A

Calculations of the fan tone acoustic power and modal structure generated by complex distortions in axial inflow velocity are presented. The model used treats the motor as a rotating three dimensional cascade and calculates the acoustic field from the distortion produced dipole distribution on the blades including noncompact source effects. Radial and circumferential distortion shapes are synthesized from Fourier Bessel components representing individual distortion modes. The relation between individual distortion modes and the generated acoustic modes is examined for particular distortion cases. Comparisons between theoretical and experimental results for distortions produced by wakes from upstream radial rods show that the analysis is a good predictor of acoustic power dependence on disturbance strength.

N79-17659\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

# COMPUTATION OF ATMOSPHERIC ATTENUATION OF SOUND FOR FRACTIONAL OCTAVE BANDS

Francis J Montegani Feb 1979 32 p refs (NASA-TP-1412, E-9763) Avail: NTIS HC A03/MF A01 CSCL 20A

Correct methods of accounting for atmospheric attenuation in band data requiring consideration of the integrated effect across the bands of the specific distance involved are discussed. Computer programs are provided that are understandable, efficient, and simple to use. It is hoped that this will facilitate more widespread use of correct computational methods, especially where routine computer processing of data is employed.

N79-20819°# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

## EXPERIMENTAL STUDY OF COAXIAL NOZZLE EXHAUST

Jack H. Goodykoontz and James R. Stone. 1979. 29 p. refs. Presented at 5th Aeroacoustics Conf., Seattle, Wash., 12-14. Mar. 1979, sponsored by AIAA.

(NASA-TM-79090; E-9914) Avail NTIS HC A03/MF A01 CSCL 20A

Experimental results are presented for static acoustic model tests of various geometrical configurations of coaxial nozzles operating over a range of flow conditions. The geometrical configurations consisted of nozzles with coplanar and non-coplanar exit planas and various exhaust area ratios. Primary and secondary nozzle flows were varied independently over a range of nozzle pressure ratios from 1.4 to 3.0 and gas temperatures from 280 to 1.100 K. Acoustic data are presented for the conventional mode of coaxial nozzle operation as well as for the inverted velocity profile mode. Comparisons are presented to show the effect of configuration and flow changes on the acoustic characteristics of the nozzles.

N79-20830\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF GEOMETRIC AND FLOW-FIELD VARIABLES ON INVERTED-V&LGCITY-PROFILE COAXIAL JET NOISE James R Stone 1979 30 p refs Presented at the 5th Aeroacoustics Conf. Seattle, 12-14 Mar. 1979, sponsored by AIAA

(NASA-TM-79095, E-9919) Avail NTIS HC A03/MF A01 CSCL 20A

Relationships between the noise generation characteristics and the flow field characteristics for inverted-velocity-profile coaxial jets are discussed. Noise measurements were made at four different sideline distances in order to determine the apparent noise source locations and flow field characteristics were determined from jet plume pressure/temperature surveys. These relationships are based on a published NASA Lewis prediction model, the basic assumptions of which are shown to be consistent with the experimental data reported herein lingrovements to the noise prediction procedure, on the basis of the present study, are included, which increase the accuracy of the high frequency noise prediction.

N79 24770\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

# AN IMPROVED METHOD FOR PREDICTING THE EFFECTS OF FLIGHT ON JET MIXING NOISE

James R Stone 1979 28 p. refs. Presented at the 97th Meeting of the Acoustical Soc of America Cambridge Mass. 11 15 Jun 1979

INASA TM 79155 E 0111 Avail NTIS HC A02/MF A01 CSCL

The NASA method (1976) for predicting the effects of flight on jet mixing noise was improved. The earlier method agreed reasonably well with experimental flight data for jet velocities up to about 520 m/sec (approximately 1700 ft/sec). The poorer agreement at high jet velocities appeared to be due primarily to the manner in which supersonic convection effects were formulated. The purely empirical supersonic convection formulation.

of the earlier method was replaced by one based on theoretical considerations. Other improvements of an empirical nature included were based on model-jet/free-jet simulated flight tests. The revised prediction method is presented and compared with experimental data obtained from the Bertin Aerotrain with a J85 engine, the DC-10 airplane with JT9D engines, and the DC-9 airplane with refanned JT8D engines. It is shown that the new method agrees better with the data base than a recently proposed SAE method.

N79-25840°# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

TONE NOISE OF THREE SUPERSONIC HELICAL TIP SPEED PROPELLERS IN A WIND TUNNEL

James H Dittmar, Robert J Jeracki, and Bernard J Blaha. 1979. 66 p. refs. Presented at 97th Meeting of the Acoustical Sociof Am., Cambridge, Mass., 11-15 Jun. 1979.

(NASA-TM-79167, E-030) Avail NTIS HC A04/MF A01 CSCL 20A

Three supersonic helical tip speed propellers were tested in the NASA Lewis 8- by 6-foot wind tunnel. This is a perforated-wall wind tunnel but it does not have acoustic damping material on its walls. The propellers were tested at tunnel through flow Mach numbers of 0.6, 0.7, 0.75, 0.8, and 0.85 with different rotational speeds and blade setting angles. The three propellers, which had approximately the same aerodynamic performance, incorporated different plan forms and different amounts of sweep and yielded different near field noise levels. The acoustically designed propeller had 45 deg of tip sweep and was significantly quieter 08 cruise than the straight bladed propeller. The intermediate 30 deg tip sweep propeller, which was swept for aerodynamic purposes, exhibited noise that was between the other two propellers. Noise trends with varying helical tip Mach number and biade loading were also observed Author

N79-25841\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

#### ASSESSMENT AT FULL SCALE OF NOZZLE/WING GEOMEYRY EFFECTS ON OTW AERO-ACOUSTIC CHARAC-TERISTICS

D Groesbeck and U vonGlahn 1979 31 p. refs (NASA-TM 79168 E-031) Avail NTIS HC A05/MF A01 CSCL 20A

The effects on acoustic characteristics of nozzle type and location on a wing for STOL engine over-the-wing configurations are assessed at full scale on the basis of model-scale data Three types of nozzle configurations are evaluated a circular nozzle with external deflector mounted above the wing, a slot nozzle with external deflector mounted on the wing and a slot nozzle mounted on the wing Nozzle exhaust plane locations with respect to the wing leading edge are varied from 10 to 46 percent chord (flaps retracted) with flap angles of 20 (takeoff altitude) and 60 (approach attitude). Perceived noise levels (PNL) are calculated as a function of flyover distance at 152 m altitude From these plots, static EPNL values, defined as flyover relative noise levels, are calculated and plotted as a function of lift and thrust ratios. From such plots the acoustic benefits attributable to variations in nozzle/deflector/wing geometry at full scale are assessed for equal aerodynamic performance. Author

N79-27930\*#. National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

# TRAILING EDGE NOISE DATA WITH COMPARISON TO THEORY

W Olsen and D Boldman 1979 30 p. refs. Presented at 12th Fluid and Plasma Dynamics Conf. Williamsburg Va., 23-25 Jul. 1979 sponsored by AIAA.

(NASA TM 79208 E 093 AIAA 79 1524) Avail NTIS HC A03/MF A01 CSCL 20A

The noise emission generated by the passage of a turbulent airstream over the trailing edge of a semi-infinite plate was measured over a large isone of airstream velocity and plate geometry. The experiment designed to validate trailing edge noise theories. The results show that the peak of the radiation

pattern moves from an upstream to a downstream direction as the velocity increases. The measured radiation pattern of the noise was in excellent agreement with that predicted by the recent theory of Goldstein. As predicted, the pattern shape was independent of the nature of the turbulence producing the noise.

N79-31002°# National Aeronautics and Space Administration.
Lewing Pasearch Center, Cleveland, Ohio.
DISPERSION OF SOUND IN A COMBUSTION DUCT BY

DISPERSION OF SOUND IN A COMBUSTION DUCT BY FUEL DROPLETS AND SOOT PARTICLES

J. H. Miles and D. D. Raftopoulos (Toledo Univ., Ohio) 1979 29 p refs. Presented at 98th Meeting of the Acoustical Soc. of Am., Salt Lake City, 26-30 Nov. 1979 (NASA-TM-79236, E-142) Avail: NTIS HC A03/MF A01 CSCL 20A

Dispersion and attenuation of acoustic plane wave disturbances propagating in a ducted combustion system are studied. The dispersion and attenuation are caused by fuel droplet and soot emissions from a jet engine combustor. The attenuation and dispersion are due to heat transfer and mass transfer and viscous drag forces between the emissions and the ambient gas. Theoretical calculations show sound propagation at speeds below the isentropic speed of sound at low frequencies. Experimental results are in good agreement with the theory.

Author

A79-19581 \* // Optimized multisectioned acoustic liners. K. J. Baumeister (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0182. 10 p. 24 refs.

A critical examination is presented of the use of optimized axially segmented acoustic liners to increase the attenuation of a tiner. New calculations show that segmenting is most efficient at high frequencies with relatively long duct lengths where the attenuation is low for both uniform and segmented liners. Statistical considerations indicate little advantage in using optimized liners with more than two segments while the bandwidth of an optimized two-segment liner is shown to be nearly equal to that of a uniform liner. Multielement liner calculations show a large degradation in performance due to changes in assumed input modal structure. Finally, in order to substantiate previous and future analytical results, in-house (finite difference) and contractor (mode matching) programs are used to generate theoretical attenuations for a number of liner configurations for liners in a rectangular duct with no mean flow. Overall, the use of optimized multisectioned liners (sometimes called phased liners) fails to offer sufficient advantage over a uniform liner to warrant their use except in low frequency single mode application. (Author)

A79-19582 \* # Modal propagation angles in a cylindrical duct with flow and their relation to sound radiation. E. J. Rice, M. F. Heidmann (NASA, Lewis Research Center, Cleveland, Ohio), and T. G. Scfrin (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.). American Institute of Aeronautics and Astronautics. Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, Paper 79-0183, 11 p. 19 refs.

The angles of propagation for the wave front making up a duct mode are presented with the Mach number in the duct. Approximate equations are derived to provide simple utilitarian expressions. These expressions are valid only near the outer wall which is the most important region since the bulk of the acoustic intensity is located there. Exact solutions using Hankel functions are given in an appendix. These data corroborate the approximate solution accuracy near the outer wall. The axial propagation angle is used to infer information about the far field radiation pattern. The resultant axial appeal of propagation in the duct is shown to agree exactly with the peak of the principal lobe to far-field radiation obtained from formal radiation calculations when the Mach number is uniform oversywhere. The obtained solution is extended to cover the case of different

Mach numbers inside and outside the duct for which exact calculations have not been available for engine inlet configurations.

A79-25946 Numerical spatial marching techniques in duct acoustics. K. J. Baumeister (NASA, Lewis Research Center, Cleveland, Ohio). Acoustical Society of America, Journal, vol. 65, Feb. 1979, p. 297-306, 23 refs.

Direct calculation of the internal structure of a ducted noise source from farfield pressure measurements is regarded as an initial value problem, where the pressure and pressure gradient (farfield impedance) are assumed to be known along a line in the farfield. If pressure and impedance are known at the boundary of the farfield, the pressure can be uniquely determined in the vicinity of the inlet and inside the inlet ducting. A marching procedure is developed which, with this information obtained from measurements, enables a description of a ducted noise source. The technique uses a finite difference representation of the homogeneous Helmholtz equation. P.T.H.

A79-26880 \* # Modal propagation angles in ducts with soft wells and their connection with suppressor performance. E. J. Rice (NASA, Lewis Research Center, Acoustics Section, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0624. 10 p. 8 refs.

The angles of propagation of the wave fronts associated with duct modes are derived for a cylindrical duct with soft walls (acoustic suppressors) and a uniform steady flow. The angle of propagation with respect to the radial coordinate (angle of incidence on the wall) is shown to be a better correlating parameter for the optimum wall impedance of spinning modes than the previously used mode cutoff ratio. Both the angle of incidence upon the duct wall and the propagation angle with respect to the duct axis are required to describe the attenuation of a propagating mode. Using the modal propagation angles, a geometric acoustics approach to suppressor acoustic performance was developed. Results from this approximate method were compared to exact modal propagation calculations to check the accuracy of the approximate method. The results are favorable except in the immediate vicinity of the modal optimum impedance where the approximate method yields about one-half of (Author)

A79-26911 \* // Effects of inflow distortion profiles on fan tone noise calculated using a 3-D theory. H. Kobayshi (NASA, Lewis Research Center, Cleveland, Ohio; National Aerospace Laboratory, Tokyo, Japan) and J. F. Groeneweg (NASA, Lewis Research Ceriter, Turbomachinery Noise Section, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0577. 11 p. 12 refs.

Calculations of the fan tone acoustic power and modal structure generated by complex distortions in axial inflow velocity are presented. The model used treats the rotor as a rotating three-dimensional cascade and calculates the acoustic field from the distortion-produced dipole distribution on the blades including noncompact source effects. Radial and circumferential distortion shapes are synthesized from Fourier-Bessel components representing individual distortion modes. The relation between individual distortion modes and the generated acoustic modes is examined for particular distortion cases. Comparisons between theoretical and experimental results for distortions produced by wakes from upstream radial rods show that the analysis is a good predictor of acoustic power dependence on disturbance strength. (Author)

A79-28963 \* # Experimental study of coaxial nozzle exhaust noise. J. H. Goodykoontz and J. R. Stone (NASA, Lewis Research Center, Jet Acoustics Branch, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0631. 29 p. 11 refs.

Experimental results are presented for static acoustic model tests of various geometrical configurations of coaxial nozzles operating over a range of flow conditions. The geometrical configurations consisted of nozzles with coplanar and non-coplanar exit planes and various exhaust area ratios. Primary and secondary nozzle flows were varied independently over a range of nozzle pressure ratios from 1.4 to 3.0 and gas temperatures from 280 to 1100 K. Acoustic data are presented for the conventional mode of coaxial nozzle operation as well as for the inverted velocity profile mode. Comparisons are presented to show the effect of configuration and flow changes on the acoustic characteristics of the nozzles. (Author)

A79-32126 \* # Effects of geometric and flow-field variables on inverted-velocity-profile coaxial jet noise and source distributions. J. R. Stone, J. H. Goodykoontz, and O. A. Gutierrez (NASA, Lewis Research Center, Jet Acoustics Branch, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0635. 27 p. 18 refs.

This paper presents relationships between the noise generation characteristics and the flow-field characteristics for inverted-velocity-profile coaxial jets. Noise measurements were made at four different sideline distances in order to determine the apparent noise source locations, and flow-field characteristics were determined from jet plume pressure/temperature surveys. These relationships are based on a published NASA Lewis prediction model, the basic assumptions of which are shown to be consistent with the experimental data reported herein. Improvements to the noise prediction procedure, on the basis of the present study, are included, which increase the accuracy of the high-frequency noise prediction. (Author)

A79-39801 \* // Tone noise of three supersonic helical tip speed propellers in a wind tunnel. J. H. Dittmar, R. J. Jeracki, and B. J. Blaha (NASA, Lewis Research Center, Cleveland, Ohio). Acoustical Society of America, Meeting, 97th, Cambridge, Mass., June 11-15, 1979, Paper, 62 p. 7 refs.

Three eight bladed supersonic helical tip speed propellers were tested in the NASA Lewis Wind Tunnel at through flow Mach numbers of 0.6, 0.7, 0.75, 0.8, and 0.85. Such propellers are being considered as propulsors for a future energy conservative aircraft. The three propellers of equal performance, incorporate different plan forms and different amounts of sweep in order to investigate their noise generation, which could cause a cabin environment problem. The acoustically designed propeller SR-3 had 45 deg of tip sweep and was significantly quieter at Mach 0.8 cruise than the straight bladed propeller, SR-2. An intermediate 30 deg tip sweep propeller, SR-1m exhibited a noise level between the other two. Enhanced pressure-time traces indicated that SR-2 and SR-1m exhibited shock-like pressure traces at Mach-0.8 cruise while the SR-3 did not. Noise trends with varying helical tip Mach number and blade loading were also observed.

M.E.P.

A79-39802 \* # Assessment at full scale of nozzle/wing yeor:atry effects on OTW aeroacoustic characteristics. D. Groesbeck and U. von Gishn (NASA, Lewis Research Center, Cleveland, Ohio). Acoustical Society of America, Meeting, 97th, Cambridge, Mass., June 11-15, 1979, Paper, 29 p. 5 refs.

The effects on acoustic characteristics of nozzle type and location on a wing for STOL engine over the-wing configurations are assessed at full scale on the basis of model scale data. Three types of nozzle configurations are evaluated a circular nozzle with external deflector mounted above the wing, a slot nozzle with external deflector mounted on the wing and a slot nozzle mounted on the wing. Nozzle exhaust plane locations with respect to the wing leading edge are varied from 10 to 46 percent chord (flaps retracted) with

flap angles of 20 deg (take-off attitude) and 60 deg (approach attitude). Perceived noise levels (PNL) are calculated as a function of flyover distance at 152 m altitude. From these plots, static EPNL values, defined as flyover relative noise levels, are calculated and plotted as a function of lift and thrust ratios. From such plots the acoustic benefits attributable to variations in nozzle/deflector/wing geometry at full scale are assessed for equal aerodynamic performance. (Author)

A79.39803 \* # An improved method for predicting the effects of flight on jet mixing noise. J. R. Stone (NASA, Lewis Research Center, Cleveland, Ohio). Acoustical Society of America, Meeting, 97th, Cambridge, Mass., June 11-15, 1979, Paper. 26 p. 20 refs.

A method for predicting the effects of flight on jet mixing noise has been developed on the basis of the jet noise th. pry of Efowcs-Williams (1963) and data delived from model-jet/free-jet simulated flight tests. Predicted and experimental values are compared for the J85 turbojet engine on the Bertin Aerotrain, the low-bypass refanned JT8D engine on a DC-9, and the high-bypass JT9D engine on a DC-10. Over the jet verocity range from 280 to 680 m/sec, the predictions show a standard deviation of 1.5 dB.

IME

A79-39975 Loudness of steady sounds - A new theory. W. L. Howes (NASA, Lewis Research Center, Cleveland, Ohio). Acustica, vol. 41, no. 5, 1979, p. 277-320, 87 refs.

A new mathematical theory for calculating the loudness of steady sounds from power summation and frequency interaction, based on psychoacoustic and physiological information, assuems that loudness is a subjective measure of the electrical energy transmitted along the auditory herve to the central nervous system. The auditory system consists of the mechanical part modeled by a bandpass filter with a transfer function dependent on the sound pressure, and the electrical part where the signal is transformed into a half-wave reproduction represented by the electrical power in impulsive discharges transmitted along neurons comprising the auditory nerve In the electrical part the neurons are distributed among artificial parallel channels with frequency bandwidths equal to 'critical bandwidths for loudness', within which loudness is constant for constant sound pressure. The total energy transmitted to the central nervous system is the sum of the energy transmitted in all channels, and the loudness is proportional to the square root of the total filtered sound energy distributed over all channels. The theory explains many psychoacoustic phenomena such as audible beats resulting from closely spaced tones, interaction of sound stimuli which affect the same neurons affecting loudness, and of individually subliminal sounds becoming audible if they lie within the same critical band.

A79-46707 \* " A statistical theory of sound radiation from a two-dimensional lined duct. Y. C. Cho (NASA, Lewis Research Center, Cleveland, Ohio, Joint Institute for Advancement of Flight Sciences, Hampton, Va.) and W. R. Watson (NASA, Langley Research Center, Hampton, Va.). American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 12th. Williamsburg, Va., July 23-25, 1979, Paper 79-1521. 5 p. 7 refs.

A statistical theory coupled with a finite element theory is employed for investigation of sound radiation from a two-dimensional fined duct. The analysis does not utilize duct modes, and can be applied to a non-uniform duct with variable wall liner properties. Numerical results are presented for various shapes of the incident wave. The results are in good agreement with the Wiener-Hopf calculation for cases where the latter can be made. (Author)

A79-47340 \* // Trailing edge noise data with comparison to theory. W. Olsen and D. Boldman (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 12th, Williamsburg, Va., July 23-25, 1979, Paper 79-1524, 28 p. 20 refs.

The noise emission generated by the passage of a turbulent airstream over the trailing edge of a semiinfinite plate was measured over a large range of airstream velocity and plate geometry. The experiment was designed to validate trailing-edge noise theories. The results show that the peak of a radiation patters moves from an upstream to a downstream direction as the velocity increases. The measured radiation pattern of the noise was in agreement with that predicted by a recent fundamental theory for leading, and trailing-edge noise. Although large changes in the character of the turbulent flow near the trailing edge effect the level and spectra of trailing-edge noise, the shape of the pattern is still accurately predicted by this theory.

V.T.

# N79-10842\*# Lockheed-Georgia Co Marietta DUCT WALL IMPEDANCE CONTROL AS AN ADVANCED CONCEPT FOR ACOUSTIC SUPPRESSION ENHANCEMENT Final Report

Peter D. Dean. Oct. 1978 - 115 p. refs (Contract NA 53-20071) (NASA-CP-1E9425 LG78ER0243) HC AGS MF A01 CSCL 20A

Avail NTIS

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A systems concept procedure is described for the optimization of acoustic duct liner design for both uniform and multisegment types. The concept was implemented by the use of a double reverberant chamber flow duct facility coupled with sophisticated computer control and acoustic analysis systems. The optimization procedure for liner insertion loss was based on the concept of variable liner impedance produced by bias air flow through a multilayer, resonant cavity liner. A multiple microphone technique for in situ wall impedance measurements was used and successfully adapted to produce automated measurements for all liner configurations jested. The complete validation of the systems concept was prevented by the inability to optimize the insertion loss using bias flow induced wall impedance changes This inability appeared to be a direct function of the presence of a higher order energy carrying modes which were not influenced significantly by the wall impedance changes ARH

# N79-14873° | Lockheed-Georgia Co. Marietta THE FREE JET AS A SIMULATOR OF FORWARD VELOCITY EFFECTS ON JET NOISE Final Report K K Abusa R J Tester and H K Tanna Oct 1978 324 p

K. K. Ahuja, B. J. Tester, and H. K. Tanna. Ort. 1978. 324 p. refs.

(Contract NAS3-20050)

(NASA-CR:3056. LG78ER0065) HC A14/MF A01 CSCL 20A Avail: NTIS

A thorough theoretical and experimental study of the effects of the free-jet shear layer on the transmission of sound from a model jet placed within the free jet to the far-field receiver located outside the free-jet flow was conducted. The validity and accuracy of the free-jet flight simulation technique for forward velocity effects on jet noise was evaluated. Transformation charts and a systematic computational procedure for converting measurements from a free-jet simulation to the corresponding results from a wind-tunnel similation, and, finally, to the flight case were provided. The effects of simulated forward flight on jet mixing noise, internal noise and shock-associated noise from model-scale unheated and heated jets were established experimentally in a free-jet facility It was illustrated that the existing anomalies between full-scale flight data and model-scale flight simulation data projected to the flight case, could well be due to the contamination of flight data by engine internal noise

Author

N79-14875\* General Electric Co., Schenectady, N. Y. Corporate Research and Development.

BASIC RESEARCH IN FAN SOURCE NOISE: INLET DISTORTION AND TURBULENCE NOISE Final Report, 16 Sep. 1976 - 16 Apr. 1978

R. A. Kantola and R. E. Warren Dec 1978 161 p refs (Contract NAS3-17853)

(NASA-CR-159451: SRD-78-186) NTIS Avail HC AOB/MF AO1 CSCL 20A

A widely recognized problem in jet engine fan noise is the discrepancy between inflight and static tests. This discrepancy consists of blade passing frequency tones, caused by ingested turbulence that appear in the static tests but not in flight. To reduce the ingested distortions and turbulence in an anechoic chamber, a reverse cone inlet is used to guide the air into the fan. This inlet also has provisions for boundary layer suction and is used in conjunction with a turbulence control structure (TCS) to condition the air impinging on the fan. The program was very successful in reducing the ingested turbulence, to the point where reductions in the acoustic power at blade passing frequency are as high as 18 db for subsonic tip speeds. Even with this large subsonic tone suppression, the supersonic tip speed tonal content remains largely unchanged, indicating that the TCS did not appreciably attenuate the noise but effects the generation via turbulence reduction. Turbulence mapping of the inlet confirmed that the tone reductions are due to a reduction in turbulence, as the low frequency power spectra of the streamwise and transverse turbulence were reduced by up to ten times and 100 times, respectively.

N79-17656\*# General Electric Co., Cincinnati, Ohio Aircraft Engine Group

EXPERIMENTAL CLEAN COMBUSTOR PROGRAM. PHASE 3: NOISE MEASUREMENT ADDENDUM Final Report

V L Doyle Dec 1978 139 p refs

(Contract NAS3 19736)

R78AEG319) NTIS (NASA-CR-159458. HC A07/MF A01 CSCL 20A

The acoustic characteristics of the double annular combustor in a CF6-50 high bypass turbofan engine were investigated Internal fluctuating pressure measurements were inade in the combust. egion and in the core exhaust. The transmission loss a 55 the turbine and nozzle was determined from the ements and compared to previous component results and theory. The primary noise source location in the combustor was investigated. Spectral comparisons of test rig results were made with the engine results. The measured overall power level was compared with component and engine correlating parame-

N79-25845\*# Virginia Polytechnic Inst and State Univ. Blacksburg

AN ANALYTICAL AND EXPERIMENTAL STUDY OF SOUND PROPAGATION AND ATTENUATION IN VARIABLE-AREA **DUCTS** Final Report

A H Nayfe's, J F Kaiser R L Marshall, and L J Hurst Oct 1078 134 p refs (Contract NAS3-18553)

(NASA-CR-135392) Avail NTIS HC A07/MF AU1 CSCL

The performance of sound suppression techniques in ducts that produce refraction effects due to axial velocity readient, was evaluated. A computer code based on the method or multiple scales was used to calculate the influence of axial variations due to slow changes in the cross-sectional area as well as transverse gradients due to the wall boundary layers. An attempt was made to verify the analytical model through direct comparison of experimental and computational results and the analytical determination of the influence of axial gradients on optimum liner properties. However, the analytical studies were unable to examine the influence of non-parallel ducts on the optimum linear conditions. For liner properties that close to optimum, the analytical predictions and the experimental measurements were compared The circumferential variations of pressure amplitudes and phases at several acial positions were examined in straight and variable-area ducts, hard-wall and lined sections with and without

a mean flow. Reasonable agreement between the theoretical and experimental results was obtained. ARH

N79-26884\* # General Electric Co., Cincinnati, Ohio. Engine Group

ACOUSTIC AND AERODYNAMIC PERFORMANCE INVES-TIGATION OF INVERTED VELOCITY PROFILE COANNULAR PLUG NOZZLES, COMPREHENSIVE DATA REPORT. VOLUME 1 Final Report

P. R. Knott, J. T. Blozy, and P. S. Staid May 1979 713 p 3 Vol

(Contract NAS3-19777)

(NASA-CR-159575-Vol-1; R79AEG166-Vol-1) Avail NTIS HC A99/MF A01 CSCL 20A

Volume 1 of a three volume report is presented. Volume 1 contains a description of the acoustic configurations, test facilities. data reduction techniques, test conditions, and detailed test results from the hot, static acoustic tests. GY

N79-26885\* # General Electric Co., Cincinnati, Ohio. Engine Group.

ACOUSTIC AND AERODYNAMIC PERFORMANCE INVES-TIGATION OF INVERTED VELOCITY PROFILE COANNULAR PLUG NOZZLES, COMPREHENSIVE DATA REPORT, **VOLUME 2** Final Report

P. R. Knott, J. T. Blozy, and P. S. Staid May 1979 523 p J Vol

(Contract NAS3-19777)

(NASA-CR-159575-Vol-2, R79AEG166-Vol-2) Avail NTIS HC A22/MF A01 C3CL 20A

Volume 2 of a three volume report is presented. Volume 2 presents acoustic data comparisons in graphic form.

N79-26886\*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group

ACOUSTIC AND AERODYNAMIC PERFORMANCE INVES-TIGATION OF INVERTED VELOCITY PROFILE COANNULAR PLUG NOZZLES, COMPREHENSIVE DATA REPORT, VOLUME 3 Final Report

P. R. Knott, J. T. Blozy, and P. S. Staid May 1979 291 p. 3 Vol.

(Contract NAS3-19777)

(NASA-CR-159575-Vol-3, R79AEG166-Vol-3) Avail NTiS HC A13/MF A01 CSCL 20A

Volume 3 of a three volume report is presented. Volume 3 contains the detailed aerodynamic test results plus the concept screening and model design report.

N79-27933\*# Lockheed Georgia Co Marietta
STUDIES OF THE ACOUSTIC TRANSMISSION CHARAC-TERISTICS OF COAXIAL NOZZLFS WITH INVERTED VELOCITY PROFILES: COMPREHENSIVE DATA REPORT Finel Report

P D Sec I. M. Salikuddin, K. K. Ahuja, H. E. Plumblee, and P. Mungur May 1979 182 p ref

(Contract NAS3-20797)

(NASA-CR-159628) Avail NTIS HC A09/MF A01 CSCL

The efficiency of internal noise radiation through a coannellar exhaust nozzle with an inverted velocity profile was studied. A prelin hary investigation was first undertaken (1) to define the test parameters which influence the internal noise radiation; (2) to develop a test methodology which could realistically be used to examine the effects of the test parameters, and (3) to validate his methodology. The result was the choice of an acoustic impulse as the internal noise source in the jet nozzles. Noise transmission characteristics of a coannular nozzle system were then investigated. In particular, the effects of fan convergence angle, cole extension length to annulus height ratio and flow Mach numbers and temperatures were studied Relevant spectral data only is presented in the form of normalized nozzle transfer function virsus nond mensional frequency

N79-32066°# Hersh Acoustical Engineering, Chatsworth, Calif EFFECT OF GRAZING FLOW ON THE ACOUSTIC IMPED-ANCE OF HELMHOLTZ RESONATORS CONSISTING OF SINGLE AND CLUSTERED ORIFICES Final Report

Alan S. Hersch and Bruce Walker Aug. 1979 183 p refs (Contract NAS3-19745)

(NASA-CR-3177) Avail: NTIS HC A09/MF A01 CSCL 20A A semiempirical fluid mechanical model is derived for the acoustic behavior of thin-walled single orifice Helmholtz resonators in a grezing flow environment. The incident and cavity sound fields are connected in terms of an orifice discharge coefficient whose values are determined experimentally using the twomicrophone method. Measurements show that at high grazing flow speeds, acoustical resistance is almost linearly proportional to the grazing flow speed and almost independent of incident sound pressure. The corresponding values of reactance are much smaller and tend towards zero. For thicker-walled orifice plates. resistance and reactance were observed to be less sensitive to grazing flow as the ratio of plate thickness to orifice diameter increased. Loud tones were observed to radiate from a single orifice Helmholtz resonator due to interaction between the grazing flow shear layer and the resonator cavity. Measurements snowed that the tones radiated at a Strouhal number equal to 0.26. The effects of grazing flow on the impedance of Helmholtz resonators consisting of clusters of orifices was also studied. In general, both resistance and reaction were found to be virtually independent of orifice relative spacing and number. These findings are valid with and without grazing flow. Author

A79-26890 \* # An impulse test technique with application to acoustic measurements. M. Salikuddin, P. D. Dean, H. E. Plumblee, Jr., and K. K. Ahuja (Lockheed-Georgia Co., Marietta, Ga.). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0679. 12 p. 13 refs. Research sponsored by the Lockheed Independent Research and Development Program; Contract No. NAS3-20797.

A method has been presented for measuring the acoustic properties of an absorbent material and a duct/nozzle system (with or without airflow) using a high voltage spark discharge as an impulse source of sound. The cross-spectra of the incident, reflected and transmitted acoustic pressure transients are analyzed by way of a FFT digital processor in the form of complex transfer functions. These transfer functions have a direct relationship to the termination impedance and radiation directivity. The impulse method has been justified by comparisons, with data obtained from existing methods (both experimental and theoretical), that show excellent agreement. Reflection coefficients and radiation impedances of various ductnozzle systems and their associated far-field directivities are also presented as some of the applications of the impulse technique.

(Author)

A79-26910 \* # Acoustic behavior of a fibrous bulk material. A. S. Hersh and B. Walker (Hersh Acoustical Engineering, Chatsworth, Calif.). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0599. 11 p. Contract No. NAS-3-19745.

A semiempirical model is presented describing the occustic behavior of Kevlar 29, a bulk absorbing material. The model is based on an approximate solution to the one-dimensional equations representing conservation of fluctuating mails, infomentum and energy. By treating the material as a momentum sink, theoretical expressions of the material complex propagation constants and characteristic impedance were derived in terms of a single constant. Evaluating the constant at a single frequency for a particular specimen, excellent agreement between prediction and measurement was achieved for a large range of sound frequencies and material porosities and thicknesses. Results show that Kevlar 29 absorbs sound efficiently even at low frequencies. This is explained in terms of a frequency dependent material phase speed. (Author)

A79-28923 \* # Noise from struts and splitters in turbofan exit ducts. M. R. Fink (United Technologies Research Center, East Hartford, Conn.). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0637. 10 p. 13 refs. Contract No. NAS3-17863.

An analytical method for calculating noise radiation from isolated airfoils in turbulent flow was combined with a method for calculating transmission of sound through a subsonic exit duct and with an empirical far field directivity shape. This combination provides a method for predicting engine internally generated noise from radial struts and stators and annular splitter rings. Calculated sound power spectra, directivity, and acoustic pressure spectra are compared with data. These data were for noise caused by a fan exit duct splitter ring, large-chord stator blades, and turbine exit struts. However, the lack of surbulence intensity and scale length measurements for these flow ducts prevented an absolute validation of the prediction method. (Author)

A79-26936 \* # Effects of simulated forward flight on jet noise, shock noise and internal noise. K. K. Ahuja, H. K. Tanna, and B. J. Tester (Lockheed-Georgia Co., Marietta, Ga.). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1973, Paper 79-0615. 11 p. 12 refs. Contract No. NAS3-20050.

Inflight simulation experiments are conducted in an anechoic free-jet facility to examine the flight effects on various combinations of jet noise, shock noise and internal noise. The jet mixing noise component reduces with forward velocity at all angles and frequencies. When jet mixing noise is contaminated with internal noise, forward motion provides a noise reduction in the rear arc and a noise increase in the forward arc, with little change at 90 deg. The results are similar for shock-containing jets. It is found that the existing anomalies between full-scale flight data and model-scale flight simulation data could well be due to the contamination of the flight data by internal noise.

(Author)

A79-28964 \* # A jet exhaust noise prediction procedure for inverted velocity profile coannular nozzles. R. S. Larson (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.). American Institute of Aeronautics and Astronautics, Aeroacoustics Conference, 5th, Seattle, Wash., Mar. 12-14, 1979, Paper 79-0633. 21 p. 26 refs. Contract No. NAS3-20061.

Acoustic model tests have demonstrated that significant noise suppression can be obtained from inverted velocity profile coannular nozzles. An acoustic prediction procedure was developed for inverted velocity profile coannular nozzles that can be used to predict SPL spectra as a function of nozzle geometry and flow conditions. In the development of this prediction procedure, the noise spectrum at a given angle was decomposed into four noise components: a low frequency mixing noise component, a high frequency mixing noise component, an outer stream shock noise component, and an inner stream shock noise component. The physics of the inverted velocity flow fixed development was used to formulate noise generation models. Scaling laws for each noise component were defined based on these models. Comparisons of predictions from this procedure with experimental data were conducted to verify the prediction procedure. (Author)

### 72 ATOMIC AND MOLECULAR PHYSICS

Includes atomic structure and molecular spectra.

N79-18711°# Minnesota Univ Minneapolis. Dept. of Electrical Engineering INVESTIGATIONS OF NEGATIVE AND POSITIVE CESIUM

### ION SPECIES Final Report

L M Chanin Sep 1978 35 p refs (Grant NsG-3094)

(NASA-CR-159446) Avail NTIS HC A03/MF A01 CSCL 20H

A direct test ided of the hypothesis of negative ion creation at the te a collector of a diode operating under conditions si ", a cesium thermionic converter. The experimental e involves using direct ion sampling through the collector ele\_ de with mass analysis using a quadrupole mass analyzer. Similar measurements are undertaken on positive ions extracted through the emitter electrode. Measurements were made on a variety of gases including pure cestum, helium-cestum mixtures and cesium-hydrogen as well as cesium-xenon mixtures. The gas additive was used primarily to aid in understanding the negative ion formation processes. Measurements were conducted using emitter (cathode) temperatures up to about 1000 F. The major negative ion identified through the collector was Cs(-) with minor negative ion peaks tentatively identified as H(-), H2(-), H3(-), He(-) and a mass 66 Positive ions detected ware believed to be Cs(+). Cs2(+) and Cs3(+).

N79-19828\* Colorado State Univ., Fort Collins.

INDUSTRIAL ION SOURCE TECHNOLOGY Annual Report Harold R. Kaufman and Raymond S. Robinson Dec. 1978 73 p refs

(Grant NsG-3086)

(NASA-CR-159534) Avail: NTIS HC A04/MF A01 CSCL 20H

An analytical model was developed to describe the development of a coned surface texture with ion bombardment and simultaneous deposition of an impurity. A mathematical model of sputter deposition rate from a beveled target was developed in conjuction with the texturing models to provide an important input to that model. The establishment of a general procedure that will allow the treatment of manay different sputtering configurations is outlined. Calculation of cross sections for energetic binary collisions was extened to Ar. Kr. and Xe with total cross sections for viscosity and diffusion calculated for the interaction energy range from leV to 1000eV Physical sputtering and reactive ion etching experiments provided experimental data on the operating limits of a broad beam ion source using CF4 as a working gas to produce reactive species in a sputtering beam Magnetic clustering effects are observed when Al is seeded with Fe and sputtered with Ar(±) ions. Silicon was textured at a micron scale by using a substrate temperature of 600 C. L.S.

# 73 NUCLEAR AND HIGH-ENERGY PHYSICS

Includes elementary and nuclear particles, and reactor theory.

For space radiation see 93 Space Radiation.

N79-12884°# TRW Defense and Space Systems Group, Redondo

Beach, Calif.

ION BEAM TECHNOLOGY APPLICATIONS STUDY Final Report

J. M Sellen, Jr 1 Nov 1978 36 p

(Contract NAS3-21027)

(NASA-CR-159437 TRW-32100-6009-RU-00) Avail NTIS HC A03/MF A01 CSCL 20H

Specific perceptions and possible ion beam technology applications were obtained as a result of a literature search and contact interviews with various institutions and individuals which took place over a 5-month period. The use of broad beam electron bombardment ion sources is assessed for materials deposition, removal, and alteration. Special techniques examined include. (1) cleaning, cutting, and texturing for surface treatment. (2) crosslinking of polymers, stress relief in deposited layers and the creation of defect states in crystalline material by ion impact, and (3) ion implantation during epitaxial growth and the deposition of neutral materials souttered by the ion beam. The aspects, advantages, and disadvantages of ion beam technology and the competitive role of alternative technologies are discussed.

N79-27975\*# Rockwell International Corp., Anaheim, Calif Electronics Research Center

### ANALYSIS AND PRELIMINARY DESIGN OF OPTICAL SENSORS FOR PROPULSION CONTROL Final Report

K. A. James, W. H. Quick, and V. H. Strahan. 23 Jan. 1979. 90 p. refs.

(Contract NAS3-21005)

(NASA-CR-159519. C79-386/501)

HC A05/MF A01 CSCL 20F

Avail NTIS

A fiber-optic sensor concept screening study was performed Twenty sensor subsystems were identified and evaluated. Two concepts selected for further study were the Fabry Perot fiber optic temperature sensor and the pulse width modulated phosphorescent temperature sensor. Various designs suitable for a Fabry Perot temperature sensor to be used as a remote fiber optic transducer were investigated. As a result a particular design was selected and constructed. Tests on this device show that spectral peaks are produced from visible white light, and the change in wavelength of the spectral peaks produced by a change in temperature is consistent with theory and is 36 nm/C for the first order peak. A literature search to determine a suitable phosphor for implementing the pulse width modulated fiber optic temperature sensor was conducted. The search indicated that such a device could be made to function for temperatures up to approximately 200 C. Materials like ZnCdS and ZnSe activated with copper will be particularly applicable to temperature sensing in the cryogenic to room temperature region. While this sensing concept is probably not applicable to jet engines, the simplicity and potential reliability make the concept highly desirable for other applications

#### 75 PLASMA PHYSICS

Includes magnetohydrodynamics and plasma fusion. For ionospheric plasmas see 46 Geophysics. For space plasmas see 90 Astrophysics.

N79-10894\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### HYDROGEN HOLLOW CATHODE ION SOURCE Patent Application

M. Mirtich, J. Sovey, and R. Roman, inventors (to NASA). 23. Oct. 1978. 8. p.

(NASA-Case LEW-12940-1; US-Patent-Appl-SN-953391) Avail NTIS HC A02/MF A01 CSCL 201

A hydrogen source is disclosed which includes a chamber having at one end a cathode which provides electrons and through which hydrogen gas flows into the chamber. Screen and accelerator grids are provided at the other end of the chamber. A baffle plate is placed between the cathode and the grids, and a cylindrical baffle is disposed coaxially with the cathode at the one end of the chamber. The cylindrical baffle is of greater diameter than the baffle plate to provide discharge impedance and also to protect the cathode from ion flux. An anode electrode draws the electrons away from the cathode. The hollow cathode includes a tubular insert of tungsten impregnated with a low work function material to provide ample electrons. A heater is provided around the hollow cathode to initiate electron emission froi. the low work function material. The source provides hydrogen or deu grium ions at a beam current density exceeding 0.1 amperes (A)/sq in and has a discharge current which can exceed 100A NASA for duty cycles of several minutes.

N79-12900\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

### ADHESIVE BONDING OF ION BEAM TEXTURED METALS AND FLUOROPOLYMERS

Michael J Mirtich and James S Sovey 1978 14 p refs Presented at the 25th Natl Vacuum Symp. San Francisco. 28 Nov - 1 Dec 1978 Sponsored by the Am Vacuum Soc (NASA-TM 79004, E-9790) Avail NTIS HC A02/MF A01 CSCL 201

An electron bombardment argon on source was used to ion etch various metals and fluoropolymers. The metal and fluoropolymers were exposed to (0.5 to 1.0) keV Ar ions at ion current densities of (0.2 to 1.5) mA/sq cm for various exposure times. The resulting surface texture is in the form of needles or spires whose vartical dimensions may range from tenths to hundreds of micrometers, depending on the selection of beam energy, ion current density, and etch time. The bonding of textured surfaces is accomplished by ion beam texturing mating pieces of either metals or fluoropolymers and applying a bonding agent which wets in and around the microscopic cons-like structures After bonding both tensile and shear strength measurements were made on the samples. Also tested, for comparison's sake, were untextured and chemically etched fluoropolymers. The results of these measurements are presented Author

N79-19867\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

### ION CONFINEMENT AND TRANSPORT IN A TOROIDAL PLASMA WITH EXTERNALLY IMPOSED RADIAL ELECTRIC FIELDS

J Reece Roth, Walter M. Krawczonek, Edward J. Powers (Texas Univ. Austin), Young C. Kim (Texas Univ., Austin), and Hae Y. Hong (Texas Univ., Austin). Mar. 1979. 86 p. refs. (NASA TP-1411, E-9754). Avail. NTIS. HC A05/MF A01. CSCL 201.

Strong electric fields were imposed elong the minor radius of the toroidal plasma by biasing it with electrodes maintained at kilovolt potentials. Coherent, low-frequency disturbances characteristic of various magnetohydrodynamic instabilities were absent in the high-density, well-confined regime. High, direct current radial electric fields with magnitudes up to 135 volts per centimeter penetrated inward to at least one-half the plasma.

radius. When the electric field pointed radially toward, the ion transport was inward against a strong local density gradient; and the plasma density and confinement time were significantly enhanced. The radial transport along the electric field appeared to be consistent with fluctuation-induced transport. With negative electrode polarity the particle confinement was consistent with a balance of two processes: a radial infusion of ions, in thuse sectors of the plasma not containing electrodes, that resulted from the radially inward fields; and ion losses to the electrodes, each of the which acted as a sink and drew ions out of the plasma. A simple model of particle confinement was proposed in which the particle confinement time is proportional to the plasma vol. 10. The scaling predicted by this model was consistent with experts. Sincal measurements.

N79 20064\* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
ION BEAM PROBING OF ELECTROSTATIC FIELDS.

Hans Persson Feb. 1979 66 p rofs (NASA-TM-X-79120; E-9953) Avail: NTIS HC A04/MF A01 CSCL 201

The determination of a cylindrically symmetric, timeindependent electrostatic potential V in a magnetic field B with the same symmetry by measurements of the deflection of a primary beam of ions is analyzed and substantiated by examples. Special attention is given to the requirements on canonical angular momentum and total energy set by an arbitrary, nonmonotone V. to scaling laws obtained by normalization, and to the analogy with ionospheric sounding. The inversion procedure with the Abel analysis of an equivalent problem with a one-dimensional fictitious potential is used in a numerical experiment with application to the NASA Lewis Modified Penning Discharge. The determination of V from a study of secondary beams of ions with increased charge produced by hot plasma electrons is also analyzed, both from a general point of view and with application to the NASA Lewis SUMMA experiment. Simple formulas and geometrical constructions are given for the minimum energy necessary to reach the axis, the whole plasma, and any point in the magnetic field. The common, simplifying assumption that V is a small perturbation is critically and constructively analyzed; an iteration scheme for successively correcting the orbits and points of ionization for the electrostatic potential is suggested. JMS

N79-22897\* Mational Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

### PRELIMINARY RESULTS IN THE NASA LEWIS H2-O2 COMBUSTION MHD EXPERIMENT

J Marlin Smith 1979 11 p refs To be presented at the 18th Symp, on the Eng. Aspects of Magnetohydrodyn., Butte, Mont., 18-20 Jun., 1979.

(NASA-TM-79135, E-9983) Avail NTIS HC A02/MF A01 CSCL 201

MHD (magnetohydrodynamic) power generation experiments were carried out in the NASA Lewis Research Center cesium-seeded H2-O2 combustion facility. This facility uses a neon-cooled cryomagnetic capable of producing magnetic fields in excess of 5 tesla. The effects of power takeoff location, generator loading, B-field stiength, and electrode breakdown on generator performance are discussed. The experimental data is compared to a theory based on one dimensional flow with heat transfer, friction, and voltage drops.

A79-14953 \*\* Microwave radiation measurements near the electron plasma frequency of the NASA Lewis Bumpy Torus plasma. R. Mallavarpu and J. R. Roth (NASA, Lewis Research Center, Cleveland, Ohio), American Physical Society, Meeting, Colorado Springs, Colo., Oct. 30-Nov. 3, 1978, Paper. 20 p. 12 refs.

Microwave emission near the electron plasma frequency of the NASA Lewis Bumpy Torus plasma has been observed, and its relation to the average electron density and the dc toroidal magnetic field was examined. The emission was detected using a spectrum analyzurarid a 50-ohm miniature coaxial probe. The radiation appeared as a broad amplitude peak that shifted in frequency as the

plasma parameters were varied. The observed radiation scanned an average plasma density ranging from 20 billion to 800 billion per cu cm. A linear relation was observed between the density calculated from the emission frequency and the average plasma density measured with a microwave interferometer. With the aid of a relative density profile measurement of the plasma, it was determined that the emissions occurred from the outer periohery of the plasma.

(Author)

A79-15597 \* # Hartmann flow with temperature-dependent physical properties. G. T. Linn (NASA, Lewis Research Center, Cleveland, Ohio) and J. S. Walker (Illinois, University, Urbana, III.). In: Developments in theoretical and applied mechanics. Volume 9-Proceedings of the Ninth Southeastern Conference, Nashville, Tenn., May 4 5, 1978. (A79-15576-04-31) Nashville, Tenn., Vanderbilt University, 1978. p. 393-401. 6 refs. NSF Grant No. ENG-74-23778.

Attention is given to the steady, fully developed, onedimensional flow of a liquid metal in which thermal conductivity, electrical conductivity, and viscosity are functions of temperature. It is found that the properties are decreasing functions of temperature and the first differences between temperature-dependent and constant properties are discussed. S.C.S.

A79-26184 \* # Velocity, temperature, and electrical conductivity, profiles in hydrogen-oxygen MHD duct flows. M. S. Greywall (Wichita State University, Wichita, Kan.) and C. C. P. Pian (NASA, Lewis Research Center, Cleveland, Ohio). In: Fluids engineering in advanced energy systems; Proceedings of the Winter Annual Meeting, San Francisco, Calif., December 10-15, 1378. (A79-26176 09-44) New York, American Society of Mechanical Engineers, 1978, p. 111-120. 8 refs. Contract No. EF-77-A-01-2647; Grant No. NsG-3186.

This paper presents results of two-dimensional duct flow computations for radial distributions of velocity, temperature, and electrical conductivity. Calculations were carried out for the flow conditions representative of NASA Lewis hydrogen-oxygen combustion driven MHD duct. Result, are presented for two sets of computations: (1) profiles of developing flow in a smooth duct, and (2) profiles of fully developed pipe flow with a specified streamwise shear stress distribution. The predicted temperature and electrical conductivity profiles for the developing flows compared well with available experimental data. (Author)

A79-39807 \* A Preliminary results in the NASA Lewis H2-02 combustion MHD experiment. J. M. Smith (NASA, Lewis Research Center, Cleveland, Ohio). Montana Energy and MHD Research and Development Institute, Montana College of Mineral Science and Technology, and Montana State University, Symposium on the Engineering Aspects of Magnetohydrodynamics, 18th, Butte, Mont., June 19-20, 1979, Paper. 9 p.

MHD power generation experiments have been carried out in the NASA Lewis Research Center cesium-seeded H2-O2 combustion facility. This facility uses a neon-confed cryomagnet capable of producing magnetic fields in excess of 5 tesla. The effects of power takeoff location, generator loading, B field strength, and electrode breakdown on generator performance are discessed. The experimental data is compared to a theory based on one-dimensional flew with heat transfer, friction, and voltage drops.

(Author)

A79.41768 \* a Trajectories of charged particles in radial electric and uniform axial magnetic fields. G. W. Englert (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Plasma Science*, vol. PS-7, June 1979, p. 72-80, 21 refs.

Trajectories of charged particles were determined over a wide range of parameters characterizing motion in cylindrical low-pressure gas rischarges and plasma heating devices which have steady radial electric fields perpendicular to uniform steady magnetic fields. Consideration was given to radial distributions characteristic of fields measured in a modified Penning discharge, in two NASA Lewis

burnout-type plasma heating devices, and that estimated for the lixion device. Numerical calculations of trajectories for such devices showed that differences between cyclotron frequency and qB/m and between azimuthal drift and a guiding center approximation are appreciable.

B.J.

A79-51995 \* # Performance optimization of an MHD generator with physical constraints. C. C. P. Pian, G. R. Seikel, and J. M. Smith (NASA, Lewis Research Center, Cleveland, Ohio). Intersociety Energy Conversion Engineering Conference, 14th, Boston, Mass., August 5-10, 1979, Proceedings. Volume 2. (A78-51726-23-44) Washington, D.C., American Chemical Society, 1979, p. 1939-1944. 7 refs.

A technique has been described which optimizes the power out of a Faraday MHD generator operating under a prescribed set of electrical and magnetic constraints. The method does not rely on complicated numerical optimization techniques. Instead the magnetic field and the electrical loading are adjusted at each streamwise location such that the resultant generator design operates at the most limiting of the cited stress levels. The simplicity of the procedure makes it ideal for optimizing generator designs for system analysis studies of power plants. The resultant locally optimum channel designs are, however, not necessarily the global optimum designs. The results of generator performance calculations are presented for an approximately 2000 MWe size plant. The difference between the maximum power generator design and the optimal design which maximizes net MHD power are described. The sensitivity of the generator performance to the various operational parameters are also (Author) presented.

A79-53867 \* Method for decomposing observed line shapes resulting from multiple causes - Application to plasma charge-exchange-neutral spectra. R. W. Patch (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Quantitative Spectroscopy and Radiative Transfer*, vol. 22, Sept. 1979, p. 273-286, 24 refs.

A method is given for decomposing the widths of observed spectral lines resulting from unresolved line splitting, additive kinetic processes of different types, instrumental broadening (slit function), Doppler broadening, etc. all superimposed. The second moments are used as measures of the various widths involved. The method is not applicable if dispersion type (Lorentz) broadening occurs. Application is made to plasma charge-exchange-neutral spectra of hydrogen, deuterium, and helium. (Author)

N79-26943\*# Colorado State Univ. Fort Collins Dept of Physics.
PHYSICAL PROCESSES IN DIRECTED ION BEAM SPUTTERING Ph.D. Thesis

Raymond S. Robinson Mar 1979 153 p refs (Grant NsG-3086)

(NASA-CR-159567) Avail NTIS HC A08/MF A01 CSCL 201

The general operation of a discharge chamber for the production of ions is described. A model is presented for the magnetic containment of both primary and secondary or Maxwellian electrons in the discharge plasma. Cross sections were calculated for energy and momentum transfer in binary collisions between like pairs of Ar. Kr. and Xe atoms in the energy range from about 1 eV to 1000 eV. These calculations were made from available pair interaction potentials using a classical model Experimental data from the literature were fit to a theoretical expression for the A. sonance charge exchange cross section over the same energy range. A model was developed that describes the processes of conical texturing of a surface due to simultaneous directed ion beam etching and sputter deposition of an impurity material. This model accurately predicts both a minimum temperature for texturing to take place and the variation of cone density with temperature. It also provides the correct order of magnitude of cone separation. It was predicted from the model, and subsequently verified experimentally, that a nigh sputter yield material could serve as a seed for coning of

a lower sputter yield substrate. Seeding geometries and seed deposition rates were studied to obtain an important input to the theoretical texturing model.

#### 76 SOLID-STATE PHYSICS

108

Includes superconductivity.

For related information, see also 33 Electronics and Electrical Engineering and 36 Lasers and Masers.

N79-13886\* National Aeronautics and Space Administration.
Lawis Research Center, Cleveland, Ohio.
IONIZED DOPANT CONCENTRATIONS AT THE MEAVILY

DOPED SURFACE OF A SILICON SOLAR CELL.
Irving W. .berg, Jacob D. Broder, George A. Mazaris, Jr., and
Lan Hst. Dec. 1978 19 p. refs

(Grant NaG-3014) (NASA-TP-1347; E-9629) Avail: NTIS HC A02/MF A01 CSCL

Data are combined with concentrations obtained by a bulk measurement method using successive layer removal with measurements of Hall effect and resistivity. From the MOS (metal-oxide-semiconductor) measurements it is found that the ionized dopant concentration N has the value (1.4 + or - 0.1) x 10 to the 20th power/cu cm at distances between 100 and 220 nm from the n(+) surface. The bulk measurement technique yields average values of N over layers whose thickness is 2000 nm. Results show that, at the Ligher concentrations encountered at the n(+) surface, the MOS C-V technique, when combined with a bulk measurement method, can be used to evaluate the effects of materials preparation methodologies on the surface and near surface concentrations of silicon cells.

Author

N79-16699°# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FRICTION AND WEAR OF SINGLE-CRYSTAL MANGANESE-ZINC FERRITE

Kazuhisa Miyoshi and Donald H. Biickley. 1979. 19 p. refs. To be presented at the Intern. Conf. on Wear of Mater., Dearborn, Mich., 16-18. Apr. 1979. sponsored by ASME, ASLE, ASM, ASTM-62, SAE, SME, Am. Chem. Soc., AIME, and APS. (NASA-TM-78980, E-9673-1). Avail. NTIS. HC A02/MF A01. CSCL 208.

Sliding friction experiments were conducted with single crystal manganese-zinc ferrite in contact with itself and with transition metals. Results indicate mating highest atomic density directions (110) on matched crystallographic planes exhibit the lowest coefficient of friction, indicating that direction is important in the friction behavior of ferrite. Matched parallel high atomic density planes and crystallographic directions at the interface exhibit low coefficients of friction. The coefficients of friction for ferrite in contact with various metals are related to the relative chemical activity of these metals. The more active the metal, the higher the coefficient of friction. Cracking and the formation of hexagon—and rectangular-shaped platelet wear debris due to cleavages of (110) planes are observed on the ferrite surfaces as a result of sliding.

Author

N79-21910\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

METHOD FOR THE PREPARATION OF INORGANIC SINGLE CRYSTAL AND POLYCRYSTALLINE ELECTRONIC MATERI-ALS Petent

Warren O Groves, inventor (to NASA) (Monsanto Co., St. Louis, Mo.) Issued 25 Feb. 1969 3 p. Filed 5 Feb. 1965. Sponsored by NASA.

(NASA-Case-XLE-02545-1, US-Patent-3,429,756;

U.S. Patent-Appl-SN-430748. U.S. Patent-Class-156-17) Avail: U.S. Patent and Trademark Office CSCL 208

carge area, semiconducto: crystals selected from group 3-5 compounds and alloys are provided for semiconductor device fabrication by the use of a selective etching operation which completely removes the substrate on which the desired crystal wait deposited. The substrate selected from the same group as the single crystal, has a higher solution rate than the epitalial single crystal which is essentially unaffected by the etching solution. The preparation of gallium phosphide single crystals

using a gallium arsenide substrate and a concentrated nitric acid etching solution is described.

A.R.H.

A79-10417 Optical, spin-resonance, and magnetoresistance studies of /tetrathiatetracene/2/iodide/3 - The nature of the ground state. R. B. Somoano, S. P. S. Yen, V. Hadek, S. K. Khanna (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.), M. Novotny (Stanford University, Stanford, Calif.), T. Datta, A. M. Hermann (Tulane University, New Orleans, La.), and J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). Physical Review B - Solid State, 3rd Series, vol. 17, Apr. 1, 19/8, p. 2853-2857, 19 refs. Contract No. NAS7-100.

A recent investigation in which Isett and Perez-Albuerne (1977) found that (tetrathiatetracene)2(iodine)3 is a stable organic metal down to 3.3 K is of considerable interest. In view of the diversity of suggestions made regarding this compound, measurements, were made of its electrical, magnetic, and optical properties. The results obtained indicate a metallic state at high temperatures, but also support a nonmetallic state at temperatures below 30 K. At 20-30 K, a metal-to-insulator phase transition occurs. This is indicated by the onset of a large and positive magnetoresistance, the leveling off in the temperature dependence of the ESR linewidth, and by recent derivative analysis of the electrical conductivity in this region. The investigated compound represents an interesting one-dimensional electronic system in which it may be possible to study the combined effects of disorder and interchain coupling on charse transport processes.

A79-20:219 \* Superconducting properties of evaporated copper molybdenum sulfide films. J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio), K. C. Chi, R. O. Dillon, R. F. Bunshah (California, University, Los Angeles, Calif.), and S. A. Alterovitz. Journal of Applied Physics, vol. 49, Dec. 1978, p. 6027-6030, 20 refs.

Films of copper molybdenum sulfide were produced by coevaporation. Those that were superconducting contained only the ternary compound and free molybdenum. The range of copper content in the ternary conipound was as large as that in polycrystalline material, that is, it includes either phase alone, or a mixture of the two phases of this material. This is in contrast with sputtered materials where copper concentration has been limited to a narrower range. The upper critical field and the critical current were measured as functions of external magnetic field, and found to be similar to those of sputtered copper molybdenum sulfide, when the comparison was made for samples having the same amount of copper. (Author)

A79-20529 Properties and performance of fine-filament bronze-process. Nb3Sn conductors. M. S. Walker, J. M. Cutro, B. A. Zeitlin, G. M. Ozeryansky, R. E. Schwall (Intermagnetics General Corp., Guilderland, N.Y.), C. E. Oberly (USAF, Wright-Patterson AFB, Ohio), J. C. Ho (Wichita State University, Wichita, Kan.), and J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). (Applied Superconductivity Conference, Pittsburgh, Pa., Sept. 25-28, 1978.) IEEE Transactions on Magnetics, vol. MAG-15, Jan. 1979, p. 80-82. 8 refs. USAF-supported research.

Fine-filament bronze-process Nb3Sn superconductors were rabricated to fulfill stringent requirements on critical current under tension in a one-inch bend diameter, current density, stability, and conductor losses. A large fraction of niobium filaments was incorporated in a bronze matrix, and a cable containing 4453 2-micron diameter filaments in each of six strands provided a current density of 85,000 A/sq cm at 10 to the -11th ohm-cm, 10 T, and 4.2 K. The next step was to incorporate copper stabilizer in a conductor with 20,538 filaments. These conductors, fabricated so that bend strains of about 1% would be experienced by the filaments in the one-inch bend, stably carried currents in the 200-500 A range. A quench current of 540 A in a 5-cm bend corresponds to 158,000 A/sq cm in the bronze and filament area, believed to be the highest critical current density reported for multifilamentary Nb3Sn. P.T.H.

A79-20539 Critical current density in wire drawn and hydrostatically extruded Nb Ti superconductors. S. A. Alterovitz, J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio), and E. W. Collings (Battelle Memorial Institute, Columbus, Ohio). (Applied Superconductivity Conference, Pittsburgh, Pa., Sept. 27 CS, 1978.) IEEE Transactions on Magnetics, vol. MAG-15, Jan. 1979, p. 404, 405. 6 refs. Contract No. W-7405-eng-92, DOE Task 64.

Critical current studies have been made on copper-clad Nb-Ti composite wire prepared under area reductions of 100:1 and 10,000:1 by hydrostatic extrusion (HE), wire drawing and HE plus drawing. Comparative evaluation of the thermomechanical processing equivalent of HE was performed.

(Author)

A79-21157 • Hall effect and magnetoresistivity in the ternary molybdenum sulfides. J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio), E. J. Haugland (NASA, Lewis Research Center; Case Western Reserve University, Cleveland, Ohio), and S. A. Alterovitz. *Physics Letters*, vol. 68A, Sept. 18, 1978, p. 122-124. 7 refs.

The Hall coefficient and magnetoresistance of sputtered films of Cu(x)MoSS8 and PbMoSS8 have been measured, as well as the magnetoresistance in sintered samples of the same materials. Assuming a single band model, net carrier densities and mean mobilities are determined. (Author)

A79-23633 Anomalous galvanomagnetic properties of graphite in strong magnetic fields. K. Sugihara (Matsushita Electric Industrial Co., Ltd., Osaka, Japan) and J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). *Physical Society of Japan, Journal*, vol. 45, Dec. 1978, p. 1891-1898, 19 refs.

A79-26375 \* Critical current and scaling laws in evaporated two-phase Cu2.5Mo6S8. S. A. Alterovitz and J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Low Temperature Physics*, vol. 32, no. 5-6, 1978, p. 839-851. 23 refs.

A79-27229 Normal state properties of the ternary molybdenum sulfides. J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio) and S. A. Alterovitz. Solid State Communications, vol. 27, no. 6, 1978, p. 669-671. 11 refs.

By making a large number of normal state and superconducting properties measurements, all on the same terriary molybdenum sulfide samples, we obtain values for Fermi surface and superconducting parameters. From these we conclude that sputtered ternary molybdenum sulfides are not completely in the dirty superconductor limit, and that they are d-band metals with a high electron carrier density. (Author)

A79 27230 Low temperature normal state resistance of ternary molybdenum sulfides. J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio) and S. A. Alterovitz. Solid State Communications, vol. 27, no. 5, 1978, p. 571 574, 27 refs.

A79-28300 \* Comparison of projected critical currents in PbMo6S8 and Nb3Ge. S. A. Alterovitz (NASA, Lewis Research Center, Cleveland, Ohio) and J. A. Woollam. *Cryogenics*, vol. 19, Mar. 1979, p. 157-169. 18 refs, NSF supported research.

Critical current densities, Jc, of sputtered Chevrel phase PbMo6S8 films have been measured as a function of field to 19 T at several temperatures. The proming forces were round to obey a scaling law. Assuming an effective upper critical field Bc2 = 45 T, an effective critical temperature 1c = 13 K, together with empirical estimates of numerical factors in the scaling law, the upper limits for critical current density. Jc in PbMo6S8 are estimated. Comparisons

are made with estimates of Jc for Nb3Ge at 4.2 K. A crossover of Jc vs. B is found for 9 of the order of 25 to 30 T. Below this point, Nb3Ge is projected to have a higher critical current density. Thus practical use of Chevrel materials in high field magnets only appears to be competitive with Nb3Ge for fields above 25 to 30 T. (Author)

A79-31973 \* Reactively evaporated films of copper molybdenum sulfide. K. C. Chi, R. O. Dillon, R. F. Bunshah (California, University, Los Angeles, Calif.), S. Alterovitz, and J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). In: Metallurgical coatings 1978; Proceedings of the Fifth International Conference, San Francisco, Calif., April 3 7, 1978. Volume 2, (A79-31951 12-23) Lausanne, Elsevier Sequoia, S. A., 1978, p. 259-262, 12 refs.

Films of superconducting Chevrel-phase copper molybdenum suifide CuxMo6S8 were deposited on sapphire substrates by reactive evaporation using H2S as the reacting gas. Two superconducting temperatures (10.0 K and 5.0 K) of the films were found, corresponding to two different phases with different copper concentrations. All films were superconducting above 4.2 K and contained Chevrel-phase compound as well as free molybden im The critical current was measured at a function of applied field. One sample was found to deviate from the scaling law found for co-evaporated or sputtered samples, which possibly indicates a different pinning mechanism of inhomogeneity of the sample. (Author)

A79-34994 \* # Friction and wear of single-crystal manganesezinc ferrite. K. Miyoshi and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio). ASME, ASLE, ASM, ASTM, SAE, SME, ACS, AIME, and APS, International Conference on Wear of Materials, Dearborn, Mich., Apr. 16-18, 1979, Paper. 17 p. 12 refs.

Sliding friction experiments were conducted with single-crystal manganese-zinc ferrite in contact with itself and with transition metals. Results indicate mating highest atomic density directions (110 line type) in matched crystallographic planes exhibit the lowest coefficient of friction indicating that direction is important in the friction behavior of ferrite. Matched parallel high atomic density planes and crystallographic directions at the interface exhibit low coefficients of friction. The coefficients of friction for ferrite in contact with various metals are related to the relative chemical activity of these metals. The impre active the metal, the higher the coefficient of friction. Cracking and the formation of hexagon- and rectangular-shaped, latelet wear debris due to cleavages are observed on the ferrite surfaces of a result of sliding. (Author)

A79-3840.2.\* The magnetocaloric effect in dysprosium. S. M. Benford (NASA, Lewis Research Genter, Cleveland, Ohio). (American Institute of Physics and Institute of Electrical and Electronics Engineers, Annual Conference on Magnetism and Magnetic Materials, 24th, Cleveland, Ohio. Nov. 14-18, 1978.) Journal of Applied Physics, vol. 50, Mar. 1979, pt. 2, p. 1868-1870, 12 refs.

The magnetocaloric effect in polycrystalline Dy was measured in the 84-280-K range in measuring fields from 1 to 7 T. Thase adiabatic temperature changes reflect structural changes in Dv with applied field and temperature, and include the first magnetocaloric data for a helical antiferromagnet. Above the Neel poin 11/2 K) a field increase always caused heating, below the Neel poin 11/2 K) at than about 2 T cause cooling for some values of initial temperature. The largest temperature increase with a 7 T field occurs at the Neel point and at fields below 2 T near the Curie point. For refrigeration purposes the optimal working region for a Dy cooling element is field dependent.

B.J.

A79-50231 \* Indirect measurements of Fermi surface parameters of some chevral phase materials. J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio) and S. A. Alterovitz Journal of Magnetism and Magnetic Materials, vol. 11, Apr. 1979, p. 177-181, 27 refs.

A series of measurements of normal state and superconducting properties were made in zero and in high magnetic fields. When these results are combined with a complete set of theoretical expressions, a number of Fermi surface parameters are found. (Author)

A 79-50233 \* Thermal expansion of some nickel and cobalt spinels and their solid solutions. I. Zaplatynsky (NASA, Lewis Research Center, Cleveland, Ohio). *British Ceramic Society, Transactions and Journal*, vol. 78, no. 1, 1979, p. 1-3. 15 refs.

N79-11921°# Case Western Reserve Univ., Cleveland, Ohio Engineering Design Canter

ADAPTATION OF ION BEAM TECHNOLOGY TO MICRO-FABRICATION OF SOLID STATE DEVICES AND TRANS DUCERS

James A Topich Nov 1978 40 p refs (Grant NsG-3131) (NASA-CR 159439) Avail NTIS HC A03/MF A01 CSCL 20L

A number of areas were investigated to determine the potential uses of ion beam techniques in the construction of solid state devices and transducers and the packaging of implantable electronics for biomedical applications. The five areas investigated during the past year were. (1) diode-like devices fabricated on textured silicon. (2) a photolithographic technique for patterning ion beam sputtered PVC (polyvinyl chloride). (3) use of sputtered Teffon as a protective coating for implantable pressure sensors. (4) the sputtering of Macor to seal implantable hybrid circuits, and (5) the use of sputtered Teffon to immobilize enzymes.

A79-44548.\* Nb3Ge as a potential candidate meterial for 15- to 25-T magnets. Wi. 9. Daniel, A. I. Braginski, C. W. Roland, J. R. Gavaler, and A. T. Santhanam (Westinghouse Research and Development Center, Pittsburgh, Pa.). In: Advances in cryogenic engineering. Volume 24 - Proceedings of the Second International Cryogenic Materials Conference, Boulder, Colo., August 2-5, 1977. (A79-44526 19-26) New York, Plenum Press, 1978, p. 459-464. 8 refs. Contracts No. NAS3 20233. No. F44620-70-C-0042.

The critical temperature, upper critical field and structure of Nb3Ge materials produced by sputtering onto sapphire or by chemical vapor deposition on sapphire or Hastelloy were determined. In the case of the samples formed by deposition, several dopants, including Nb5Ge3, NbN and NbC were used. A variety of deposition temperatures were studied. Highest upper critical field values were obtained in samples deposited in the 750 to 850 C range. The degree of flux pinning exhibited a correlation with grain size. The presence of an impurity dopant had a depressant effect on the critical temperature and upper critical field.

C.K.D.

# 77 THERMODYNAMICS AND STATISTICAL PHYSICS

Includes quantum mechanics; and Bose and Fermi statistics

For related information see also 25 Inorganic and Physical Chemistry and 34 Fluid Mechanics and Heat Transfer

A79-41731 \* Electronic properties of PbMo6S8 and CuxMo6S8. J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio) and S. A. Alterovitz (NASA, Lewis Research Center, Cleveland, Ohio; Tel Aviv University, Tel Aviv, Israel). Physical Review B - Solid State, 3rd Series, vol. 19, Jan. 15, 1979, p. 749-761.

Normal-state properties of sputtered, evaporated, and sintered PbMo6S8 and CuxMo6S8 (where x is between 1.6 and 2.5) samplus are reported. These include the temperature dependence of resistivity, magnetoresistance and Hall effect. When combined with superconducting properties (measured on the same samples) and theory, a number of Fermi-surface and superconducting parameters are derived. Fits to the temperature dependence of the resistivity are compared with similar fits for A.15 structure superconductors.

(Author)

A79-49532 \* # Energy-state formulation of lumped volume dynamic equations with application to a simplified free piston Stirling engine. C. J. Daniels and C. F. Lurenzo (NASA, Lewis Research Center, Cleveland, Ohio). International Conference on Energy and the Environment, 6th, Pittsburgh, Pa., May 21-24, 1979, Paper, 28 p. 8 refs.

Lumped volume dynamic equations are derived using an energy-state formulation. This technique requires that kinetic and potential energy state functions be written for the physical system being investigated. To account for losses in the system, a Rayleigh dissipation function is also formed. Using these functions, a Lagrangian is formed and using Lagrange's equation, the equations of motion for the system are derived. The results of the application of this technique to a lumped volume are used to derive a model for the free-piston. Stirling engine. The model was simplified and programmed on an analog computer. Results are given comparing the model response with experimental data.

(Author)

# 85 URBAN TECHNOLOGY AND TRANSPORTATION

Includes applications of space technology to urban problems; technology transfer; technology assessment; and surface and mass transportation.

For related information see 03 Air Transportation and Safety, 16 Space Transportation, and 44 Energy Production and Conversion.

N79-11956\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

FUEL CELL ON-SITE INTEGRATED ENERGY SYSTEM PARAMETRIC ANALYSIS OF A RESIDENTIAL COMPLEX Stephen N Simons [1977] 25 p refs Presented at the Fuel Cell Workshop, Sarasota. Fla 14-17 Nov 1977 sponsored by DOF

(NASA TM 78996, E 9780) Avail NTIS HC A02/MF A01 CSCL 108

A parametric energy use analysis was performed for a large apartment complex served by a fuel cell on site integrated energy system (OS/IES). The variables parameterized include operating characteristics for four phosphoric acid fuel cells, eight OS/IES energy recovery systems, and four climatic locations. The annual fuel consumption for selected parametric combinations are presented and a breakeven economic analysis is presented for one parametric combination. The results show fuel cell electrical efficiency and system component choice have the greatest effect on annual fuel consumption, fuel cell thermal efficiency and geographic location have less of an effect.

Authorized.

N79-16721\*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

IN'TIAL COMPARISON OF SINGLE CYLINDER STIRLING ENGINE COMPUTER MODEL PREDICTIONS WITH TEST RESULTS

Roy C. Tew, Jr., Lanny G. Thieme, and David Miao. 1979. 37 p. refs. Presented at the Intern. Congr. and Exposition, Detroit, 26 Feb. 1979. 4 Mar. 1979, sponsored by the Soc. of Automotive Engr.

(Contract EC-77-A-1-1040)

(NASA-TM 79044, DOE/NASA/1040-78/30, E-9848) Avail NT'S HC A03/MF A01 CSCL 10B

A Stirling engine digital computer model developed at NASA Lewis Research Center was configured to predict the performance of the GPU-3 single-cylinder rhombic drive engine. Revisions to the basic equations and assumptions are discussed. Model predictions with the early results of the Lewis Research Center GPU-3 tests are compared.

N79-27023\*# National Aeronautics and Space Administration Lewis Research Center: Cleveland, Ohio

LOW-POWER BASELINE TEST RESULTS FOR THE GPU 3 STIRLING EL. NE Final Report

Lanny G. Thie. J. Apr. 1979, 68 p. refs. Document includes nicrofiche supplement. Supplement is available from NTIS (Contract EC 77-A 31-1040).

(NASA-TM 79103 E-9927 DOE/NASA/1040-79/6) Avail NTIS HC E04/MF A01 CSCL 10B

A 7 5 kW (10 hp) Stirling engine was converted to a research configuration in order 10 obtain data for validating Stirling cycle computer simulations. Test results for a range of heater-tube gas temperatures, mean compression-pace pressures, and engine speeds with both helium and hydrogen as the working fluid are summarized. An instrumentation system to determine indicated work is described and preliminary results are presented.

A79-37293 \* # A cycle timer for testing electric vehicles. R. F. Soltis (NASA, Lewis Research Center, Cleveland, Ohio). Electric Vehicle Council, International Electric Vehicle Symposium, 5th, Philadelphia, Pa., Oct. 2-5, 1978, Paper. 10 p. Contract No. EC-77-A-31-1011.

The paper presents a cycle timer which enables the accurate following and repetition of SAE driving schedules of stop and go cycles, for electric vehicles, by reducing the human factor. The system which consists of a programmable read-only memory (PROM) stores each of these cycles, which are detailed, on its own plug-in card. The actual vehicle speed, and the PROM indicated desired speed are displayed on a dual scale meter allowing the driver to match them. A speed change is preceded by a half second buzzer warning and a new cycle by a one second warning. The PROM controls the recycle start time as well as the buzzer activation. A 5 volt regulator providing logic power, and a 12 volt dc-dc converter providing analog and memory power are described.

M.E.P.

N79-12988\* Booz-Allen and Hamilton, Inc., Cleveland, Chio Design and Development

PRELIMINARY POWER TRAIN DESIGN FOR A STATE-OF-THE-ART ELECTRIC VEHICLE (EXECUTIVE SUMMARY) [1978] 119 p

(Contract NAS3-20595)

(NASA-CR-157625) Avail NTIS HC A09/MF A01 CSCL 13F

The preliminary design of a state-of-the-art electric power train is part of a national effort to reap the potential benefit of useful urban electric passenger vehicles. Outlined in a detailed presentation are (1) assessment of the state-of-the-art in electric vehicle technology. (2) state-of-the-art power train design. (3) improved power train, and (4) summary and recommendations.

N79-12989\*# Ford Motor Co., Dearborn, Mich EVALUATION OF ADVANCED REGENERATOR SYSTEMS J. A. Cook, C. A. Fucinari, J. N. Lingscheit, and C. J. Rahnke Aug. 1978 39 p. refs. (Contract DEN3.8)

(NA SA - CR - 159422 , D OE/NASA/0008-78/4) Avail NTIS HC A03/MF A01 CSCL 13F

The major considerations are discussed which will affect the selection of a ceramic regenerative heat exchanger for an improved 100 HP automotive gas turbine engine. The regenerator considered for this application is about 36cm in diameter. Regenerator comparisons are made on the basis of material, method of fabrication, cost, and performance. A regenerator inlet temperature of 1000 C is assumed for performance comparisons, and laboratory test results are discussed for material comparisons at 1100 and 1200 C. Engine test results using the Ford 707 industrial gas turbine engine are also discussed.

Author

### N79.29110\*# Mechanical Technology, Inc. Latham, N.Y. CONCEPTUAL DESIGN STUDY OF AN AUTOMOTIVE STIRLING REFERENCE ENGINE SYSTEM

Jun 1979 31 p. Prepared for NASA and JOE (Contracts DEN3 32 EC 77 A 31 10040) (NASA CR 159605 MTI 79ASE53RE1A

DOE NASA 0032 79 11 Avail NTIS HC A03 MF A01 CSCL 13F

The studies that were made the methodology that was used and the results which support the concluded recommendation of a four cylinder double acting square. U design with external regenerators are described. Optimization of this design concept resulted in a calculated fuel economy of 36.3 mpg for a 3200 pound vehicle compared to the program goal of 30.0 mpg and acceleration time of 13.1 seconds compared to the program goal of 15.0 seconds. The engine will meet or exceed the program emission goals of HC = 0.41 gram/mile. CO = 3.4 gram/mile and nitrogen oxide = 0.4 gram/mile. A R H

N79-31087°# Detroit Diesel Allison, Indianapolis, Ind CONCEPTUAL DESIGN STUDY OF AN IMPROVED GAS TURBINE (IGT) POWERTRAIN Report, Mar. - Nov. 1978 R A Johnson Jul 1979 241 p refs Revised (Contract DEN3-28)

(NASA CR-159604, DDA-EDR-9719, DOE/NASA/0028-79/1) Avail NTIS HC A11/MF A01, CSCL 13F

Design concepts for an improved automotive gas turbine powertrain are discussed. Twenty percent fuel economy improvement (over 1976), competitive costs (initial and life cycle), high reliability/life, low emissions, and noise/safety compliance were among the factors considered. The powertrain selected consists of a two shaft gas turbine engine with variable geometry aerodynamic components and a single disk rotating regenerator The regenerator disk, gasifier turbine rotor, and several hot section flowpath parts are ceramic. The powertrain utilizes a conventional automatic transmission. The closest competitor was a single shaft turbine engine matched to a continuously variable transmission (CVT) Both candidate powertrain systems were found to be similar in many respects, however, the CVT represented a significant increase in development cost, technical risk, and production start up costs over the conventional automatic transmission Installation of the gas turbine powertrain was investigated for a transverse mounted front wheel drive vehicle

N79-31088\*# Ford Motor Co. Dearborn, Mich.
CONCEPTUAL DESIGN STUDY OF IMPROVED AUTOMOTIVES GAS TURBINE POWERTRAIN Final Report

May 1979 215 p. refs. Prepared in cooperation with AiResearch Mfg. Co., Phoenix, Ariz

(Contracts DEN3 37 EC 77 A 31 1040)

(NASA-CR-15.7580 DOE/NASA/0037-79/1) Avail NTIS HC A10/MF A01 CSCL 13F

Twenty-two candidate engine concepts and nineteen transmission concepts. Screening of these concepts predominantly for fuel economy, cost and technical risk resulted in a recommended powertrain consisting of a single-shaft erigine, with a ceramic radial turbine rotor connected through a differential split power transmission utilizing a variable stator torque converter and a four speed automatic gearbox. Vehicle fuel economy and performance projections, preliminarly design analyses and installation studies in a were completed. A cost comparison with the conventional spark ignited gasoline engine showed that the turbine engine would be more expensive initially however lifetime cost of ownership is in favor of the gas turbine. A ; wentrain research, and development plan was constructed to gain information on timing and costs to achieve the required level of technology and demonstrate the engine in a vehicle by the year 1983.

#### N79 32129\* Detroit Diesel Allison Indianapolis Ind SINGLE SHAFT AUTOMOTIVE GAS TURBINE ENGINE CHARACTERIZATION TEST Final Report

R A Johnson Sep 1979 103 p Prepared for NASA and DOE

(Contracts DEN3 4 EC 77 A 31 1040)

(NASA CR 159654 DDA EDR 9790 DOE NASA, 0004 79 | 1) Avail NTIS HC A06 MF A01 CSCL 13F

An automotive gas turbine incorporating a single stage centrifugal compressor and a single stage radial inflow turbine is described. Among the engine's features is the use of wide range variable geometry at the inlet guide varies the compressor diffuser varies and the turbine inlet varies to achieve improved part load fuel economy. The engine was tested to determine its performance in both the variable geometry and equivalent fixed geometry modes. Testing was conducted without the originally designed recuperator. Test results were compared with the predicted performance of the nonrecuperative engine based on existing componenting test maps. Agreement between test results and the computer model was achieved.

A W H

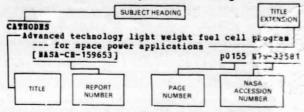
#### 99 GENERAL

A79-21277 \* # Engineering in the 21st century. J. F. McCarthy, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). American Astronautical Society, Anniversary C. oference, 25th, Houston, Tex., Oct. 30-Nov. 2, 1978, Paper 78-192, 14 p. 11 refs.

A description is presented of the nature of the aerospace technology system that might be expected by the 21st century from a reasonable evolution of the current resources and capabilities. An aerospace employment outlook is provided. The years 1977 and 1978 seem to be marking the beginning of a period of stability and moderate growth in the aerospace industry. Aerospace research and development employment increased to 70,000 in 1977 and is now occupying a near-constant 18% share of the total research and development work force. The changing job environment is considered along with the future of aerospace education. It is found that one trend is toward a more interdisciplinary education. Most trend setters in engineering education recognize that the really challenging engineering problems invariably require the judicious exercise of several disciplines for their solution. Some future trends in aerospace technology are discussed. By the year 2000 space technology will have achieved major advances in four areas, including management of information, transportation, space structures, and energy.

# SUBJECT INDEX

Typical Subject Index Listing



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[MASA-CB-159536] p0130 N79-31627  ELASTORIDEOUTHABICS The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0116 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielected electron beams  Area scaling investigations of a discharge pulse characteristics.	effects in  p0048 A79-30139 ductivity on the trics exposed to  p0171 A79-50938 charging phenomena
[MASA-CR-1595]6] p0130 N79-31827  BLASTORIDBODINANICS The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielected electron beams  Area scaling investigations of compositions.	effects in  p0048 A79-30139 ductivity on the trics exposed to  p0171 A79-50938 charging phenomena istics of Teflon
[MASA-CR-159536] p0130 N79-31627  ELASTORYDBODYBANICS The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielected electron beams  Area scaling investigations of componential control tape	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032
[MASA-CB-159536] p0130 N79-31627  ELASTORYDRODYBARICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0116 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface conceptorential developed by dielected electron beams  Area scaling investigations of control tape  MASCAF modelling of environments	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032
[MASA-CR-1595]6] p0130 N79-31827  BLASTORIDBODINANICS The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASLF PREPERNT 78-LC-1A-1] p0118 A79-23267	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielect electron beams  Area scaling investigations of a discharge pulse characterithermal control tape  WASCAF modelling of environmenta discharges in satellites	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032 al-charging-induced
[MASA-CR-159536] p0130 N79-31827  ELASTORYDBODYBABICS The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASLF PREPRINT 78-LC-1A-1]  Two-dimensional random surface model for	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielected electron beams  Area scaling investigations of control teams control tape  NASCAF modelling of environment discharges in satellites [NASA-TB-79247]	p0048 A79-30139 ductivity on the trics exposed to  p0171 A79-50938 charging phenomena istics of Teflon  p0048 B79-24032 al-charging-induced  p0048 B79-31265
[MASA-CB-159536] p0130 N79-31627  ELASTORYDBODYNABICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starwed conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASIF PREPRINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface conceptor of the second potential developed by dielect electron beams  Area scaling investigations of control tape  MASCAF modelling of environment discharges in satellites [MASA-TM-79247] Discharge characteristics of 300	p0048 A79-30139 ductivity on the trics exposed to  p0171 A79-50938 charging phenomena istics of Teflon  p0048 B79-24032 al-charging-induced  p0048 B79-31265
[MASA-CR-1595]6] p0130 N79-31827  ELASTORIDBODINANICS The practical impact of elastohydrodynamic lubrication  p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASLF PREPRINT 78-LU-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39811	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielect electron beams  Area scaling investigations of electron beams  Macar modelling of environment discharges in satellites [NASA-TM-79247] Discharge characteristics of 300 traction cells	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032 al-charging-induced p0048 B79-31265 dampere-bour Ni-Zr
[MASA-CB-159536] p0130 N79-31627  ELASTORYDBODYNABICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starwed conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASIF PREPRINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielected electron beams  Area scaling investigations of electron beams  Area scaling investigations of electron beams  MASCAF modelling of environments discharges in satellites [MASA-TM-79247]  Discharge characteristics of 300 traction cells [MASA-TM-79244]	p0048 A79-30139 ductivity on the trics exposed to  p0171 A79-50938 charging phenomena istics of Teflon  p0048 B79-24032 al-charging-induced  p0048 B79-31265
[MASA-CR-159536] p0130 N79-31627  ELASTORYDBOD HARMICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings  [ASLE PREPRINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39811  Determination of lubricant selection based on	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface conceptor of the spacecraft charging phenomena developed by dielect electron beams  Area scaling investigations of control tape with the spacecraft characteristic and control tape  MASCAF modelling of environment discharges in satellites [MASA-TM-79247]  Discharge characteristics of 300 traction cells [WASA-TM-79244]  ELECTRIC EMBEGY STORAGE	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032 al-charging-induced p0048 B79-31265 ampere-hour Ni-Zm
[MASA-CR-1595]6] p0130 N79-31827  ELASTORIDBODINANICS The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASLF PREPRINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39819  Determination of lubricant selection based on elastohydrodynamic film thickness and traction measurement	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielect electron beams  Area scaling investigations of an edge of the e	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032 al-charging-induced p0048 B79-31265 ampere-hour Ni-Zm
[MASA-CR-159536] p0130 N79-31827  ELASTORYDBODYBANICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASLE PAPERINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39811  Determination of lubricant selection based on elastohydrodynamic film thickness and traction measurement [MASA-CR-159428] p0121 M79-14385	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielected electron beams  Area scaling investigations of electron beams  Area scaling investigations of electron tacks are pulse characteristhermal control tape  MASCAF modelling of environments discharges in satellites [MASA-TM-79247]  Discharge characteristics of 300 traction cells [WASA-TM-79244]  ELECTRIC EMERGE STORAGE  Electrochemical cell for rebalar system	p0048 A79-30139 Suctivity on the trics exposed to p0171 A79-50938 Charging phenomena istics of Teflon p0048 B79-24032 al-charging-induced p0048 B79-31265 D ampere-bour Ni-Zn p0143 B79-31781
[MASA-CR-159536] p0130 N79-31627  ELASTORYDRODYNAMICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starwed conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASIE PREPRINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39811  Determination of lubricant selection hased on elastohydrodynamic film thickness and traction measurement [NASA-CR-159428] p0121 N79-14385  Two-dimensional random surface model for	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielect electron beams  Area scaling investigations of electron beams  Area scaling investigations of electron beams  MASCAF modelling of environment discharges in satellites [MASA-TB-79247]  Discharge characteristics of 300 traction cells [MASA-TB-79244]  ELECTRIC EMERGY STORAGE Electrochemical cell for rebalar system [WASA-CASE-LEW-13150-1]	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenosena istics of Teflon p0048 B79-24032 al-charging-induced p0048 B79-31265 ampere-hour Bi-Zm p0143 B79-31781 acing BEDOX flow p0139 B79-26474
[MASA-CR-159536] p0130 N79-31827  ELASTORYDBODYBANICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASLE PAPERINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39811  Determination of lubricant selection based on elastohydrodynamic film thickness and traction measurement [MASA-CR-159428] p0121 M79-14385	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielected electron beams  Area scaling investigations of electron beams  Area scaling investigations of electron tacks are pulse characteristhermal control tape  NASCAF modelling of environments discharges in satellites [NASA-TM-79247]  Discharge characteristics of 300 traction cells [NASA-TM-79244]  ELECTRIC EMERGE STORMAGE Electrochemical cell for rebalar system	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032 al-charging-induced p0048 B79-31265 dampere-bour Ni-Zn p0143 B79-31781 acing BEDOX flow p0139 B79-26474 sic power system
[MASA-CR-1595]6] p0130 N79-31827  BLASTORIDBODINANICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASLF PREPRINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39819  Determination of lubricant selection based on elastohydrodynamic film thickness and traction measurement [NASA-CR-159428]  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication	vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielect electron beams  Area scaling investigations of a discharge pulse characters thermal control tape  NASCAF modelling of environmentadischarges in satellites [NASA-TM-79247] Discharge characteristics of 300 traction cells [NASA-TM-79244]  ELECTRIC EMEMORY STORAGE Electrochemical cell for rebalar system [NASA-CASE-LEW-13150-1] Dynamic analysis of a photovolte	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032 al-charging-induced p0048 B79-31265 dampere-bour Ni-Zn p0143 B79-31781 acing BEDOX flow p0139 B79-26474 sic power system
[MASA-CR-159536] p0130 N79-31827  ELASTORYDBODYBANICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASME PAPERINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39811  Determination of lubricant selection based on elastohydrodynamic film thickness and traction measurement [MASA-CR-159428]  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication [MASA-TM-79006] p0115 N79-23430	Vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielect electron beams  Area scaling investigations of electron beams  Area scaling investigations of electron tape  MASCAF modelling of environments discharges in satellites [MASA-TM-79247]  Discharge characteristics of 300 traction cells [WASA-TM-79244]  ELECTRIC EMEMORY STORMORE  Electrochemical cell for rebalar system [NASA-CASE-LEW-13150-1]  Dynamic analysis of a photovolta with battery storage capability	p0048 A79-30139 ductivity on the trics exposed to  p0171 A79-50938 charging phenomena istics of Teflon  p0048 B79-24032 al-charging-induced  p0048 B79-31265 0 ampere-bour Ni-Zb  p0143 B79-31781 acing REDOX flow  p0139 B79-26874 aic power system
[MASA-CB-1595]6] p0130 N79-31827  ELASTORYDBODYBARICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starwed conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASLE PREPRINT 78-LC-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39811  Determination of lubricant selection based on elastohydrodynamic film thickness and traction measurement [NASA-CB-159428] p0121 N79-14385  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication [NASA-CB-159428] p0115 N79-23430  Elastohydrodynamic film thickness measurements of	Vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielect electron beams  Area scaling investigations of electron beams  Area scaling investigations of electron beams  Area scaling investigations of electron beams  MASCAF modelling of environment discharges in satellites [MASA-TR-79247]  Discharge characteristics of 300 traction cells [MASA-TR-79244]  ELECTRIC EMERGY STORAGE  Electrochemical cell for rebalar system  [NASA-CASE-LEW-13150-1]  Dynamic analysis of a photovolt with battery storage capability [MASA-TR-79209]	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032 al-charging-induced p0048 B79-31265 D ampere-bour Bi-ZE p0143 B79-31781 acing BEDOX flow p0139 B79-26474 aic power system ty p0142 B79-29599
[MASA-CR-159536] p0130 N79-31827  ELASTORIDBODINANICS  The practical impact of elastohydrodynamic lubrication p0117 A79-11545  Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus.  II - Starved conjunction [ASME PAPER 78-LUB-1] p0118 A79-23229  Effect of geometry on hydrodynamic film thickness [ASME PAPER 78-LUB-24] p0118 A79-23237  Elastohydrodynamic film thickness measurements of artificially produced surface dents and grooves on fatigue failure of bearings [ASLF PREPRINT 78-LU-1A-1] p0118 A79-23267  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication p0120 A79-39819  Determination of lubricant selection hased on elastohydrodynamic film thickness and traction measurement [NASA-CR-159428] p0121 N79-14385  Two-dimensional random surface model for asperity-contact in elastohydrodynamic lubrication [NASA-TB-79006] p0115 N79-21430  Elastohydrodynamic film thickness measurements of artificially produced nonsmooth surfaces	Vehicles  Insulator edge voltage gradient spacecraft charging phenomena  Effects of bulk and surface compotential developed by dielect electron beams  Area scaling investigations of a discharge pulse characters thermal control tape  NASCAF modelling of environments discharges in satellites [NASA-TM-79247]  Discharge characteristics of 300 traction cells [NASA-TM-79244]  ELECTRIC EMEMORY STORAGE  Electrochemical cell for rebalar system [NASA-CASE-LEW-13150-1]  Dynamic analysis of a photovolte with battery storage capability (NASA-TM-79209)  ELECTRIC EGUIPHERNI TESTS	p0048 A79-30139 ductivity on the trics exposed to p0171 A79-50938 charging phenomena istics of Teflon p0048 B79-24032 al-charging-induced p0048 B79-31265 D ampere-bour Bi-ZE p0143 B79-31781 acing BEDOX flow p0139 B79-26474 aic power system ty p0142 B79-29599
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	p0086 A79-21291	NT ION ENGINES	
RESINS NT EPOXY RESINS		NT LIQUID PROPELLANT BOCKET ENGINE NT MERCURY ION ENGINES	ES
NT KEVLAS (IRADEMARK)		Convective heat flux in a laser-	-heated thruster
HT PHENGLIC RESINS			F0057 A79-22396
NT POLYETHER RESINS		Some effects of cyclic induced of	deformation in
NT ECLYTHIDE RESINS Hethod of cross-linking polyvinyl a	lcohol and	rocket thrust chambers [AIAA 79-0911]	p0054 A79-34736
other water soluble resins	200202 000	Advanced electrostatic ion thru:	
[NASA-CASE-LEW-13103-1]	p0068 N79-14172	propulsion	
BESISTIVITY U ELECTRICAL RESISTIVITY		[MASA-CR-159406] Increased capabilities of the 3	p0056 N79-14153
RESONANCE		ion thruster	o ca didaecer by
NT ELECTRON PARAMAGNETIC RESONANCE		[NASA-TM-79142]	p0053 N79-22192
NT BESONANT VIBRATION		BOCKET LAUNCHING	
HT SPIN RESONANCE RESONANT CAVITIES		NT LUNAR LAUNCH BOCKET LININGS	
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RESOBANT PREQUENCIES		lining	-0100 270 21212
Design, fabrication, and initial te for reducing the natural frequenc		[NASA-CASE-LEW-12441-2] Effect of low-stiffness closeou	p0104 N79-21313
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[NASA-TH-79200]	p0142 N79-28727	[NASA-TP-1456]	p0053 N79-23132
Experimental evaluation of the effe	ct of inlet	FOCKET MOTOR CASES U HOCKET ENGINE CASES	
distortion on compressor blade vi		BOCKET PROPELLANT TANKS	
[ NA SA-TH-79066 ]	p0126 N79-16300	U PROPELIANT TANKS	
RESONATORS NT CAVITY RESONATORS		BCCKET PROPELLANTS NT CHYOGENIC BOCKET PROPELLANTS	
PESOGRCBS		NT GASEOUS BOCKET PROPELLANTS	
NT COAL		NT LIQUID ROCKET FROPELLANTS	
NT CHUDE OIL		BOCKET VEHICLES	
NT FOSSIL FUELS NT ICEBERGS		NT ATLAS LAUNCH VEHICLES NT CENTAUR LAUNCH VEHICLE	
NT FOSSIL FUELS NT ICEBERGS BESPONSES		NT CENTAUR LAUNCH VEHICLE BOCKS	
NT ICEBERGS RESPONSES NT DINAMIC BESPONSE		NT CENTAUR LAUNCH VEHICLE BOCKS NT COAL	
NT ICEBERGS RESPONSES NT PTABLIC RESPONSE NT MODAL RESPONSE		NT CENTAUR LAUNCH VEHICLE BOCKS NT COAL BODS	of interaction
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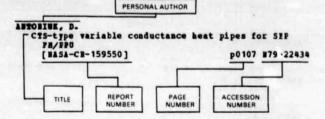
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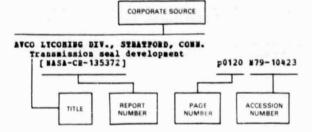
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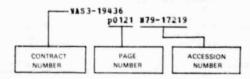
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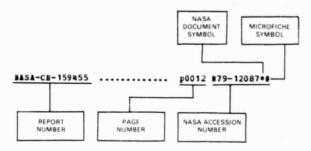
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AIFESEARCH-31-2935-1 AIRESEARCH-31-2935-2 AIFESEARCH-31-2936 AIFESEARCH-31-2937 AIRESEARCH-78-14972  AL78P022-VOL-1 AL78P023-VOL-2 AL78T007  ASLE PREPRINT 78-LC-1A-1 ASLE PREPRINT 78-LC-3C-1 ASLE PREPRINT 78-LC-5C-2  ASME PAPER 78-GT-128 ASME PAPER 78-LUE-1 ASME PAPER 78-LUE-1 ASME PAPER 78-LUE-1 ASME PAPER 78-LUE-18 ASME PAPER 78-LUE-34 ASME PAPER 78-LUB-34 ASME PAPER 78-LUB-34 ASME PAPER 78-DE-5 ASME PAPER 79-DE-5 ASME PAPER 79-DE-5 ASME PAPER 79-GT-5 ASME PAPER 79-GT-6 ASME PAPER 79-GT-6 ASME PAPER 79-GT-19 ASMF PAPER 79-GT-38	P0120 N79-11408*#   P0120 N79-11409*#   P0120 N79-11407*#   P0150 N79-11407*#   P0150 N79-11476*#   P0151 N79-11476*#   P0151 N79-17222*#   P0121 N79-17223*#   P0121 N79-17219*#   P0118 N79-23251*   P0123 N79-23251*   P0123 N79-23251*   P0118 N79-23225*#   P0118 N79-23235*#   P0118 N79-23237*#   P0118 N79-23237*#   P0118 N79-23237*#   P0118 N79-23237*#   P0118 N79-30504*#   P0028 N79-30504*#   P0028 N79-30504*#   P0028 N79-30553*#   P0147 N79-30555*#   P0147 N79-30555*#
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	-		DOE/WASA/ .28-79/23 p0142 W7	79-30719*#
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AVRADCOM-TR-78-36			DCE/NASA/1034-78/3 p0134 N7	
AVRADCOM-TR-78-38 (PL)	p0013	N79-11043*#	DOE/NASA/1034-79/1 p0137 N7	79-21550*#
AVRADCOM-TR-78-41	p0015	N79-14099*#	DOE/WASA/1034-79/2 p0136 W7	79-20498**
AVRADCOM-T8-78-42			DOE/NASA/1040-78/4 p0134 N7	
AVRA DCOM-TR-78-47			DOE/WASA/1040-78/5 p0135 N7	
AVRACCOM-TE-78-48	p0115	N79-23430*#	DOE/NASA/1040-78/30 p0188 N7	79-16721**
AVRADCOM-TR-78-49	p0023	N79-27143+#	DOE/MASA/1040-79/6 p0188 N7	79-27023**
AVRADCOM-TR-78-52				
AVRACCOM-TR-78-54			DOE/NASA/1044-79/2 p0098 N7	
AVRADCOM-TR-78-59	p0073	N79-12203**	DOE/NASA/1044-79/3 p0142 N7	79-28728**
AVRADCOM-TR 78-62	p0061	N79-16075**	DOE/NASA/1059-79/2 p0140 N7	79-26504**
AVRADCOM-TR-78-63			DOE/HASA/1060-78/1 p0139 N7	
AVRADCOM-TR-79-4	p0001	N79-20008**	DOE/WASA/1062-79/1	79-24444*
AVRADCOM-TB-79-6	p0062	N79-16920**	DOE/HASA/1062-79/2 p0141 N7	79-27665*#
AVRADCOM-TR-79-10			DOE/NASA/1892-78/1 p0151 N7	
AVRA DCOM-TB-79-12	P0018	M/9-23908**	DOE/NASA/2593-78/3 p0073 N7	
AVRADCOM-TR-79-18	p0018	N79-23964**	DOE/NASA/2593-78/4 p0135 N7	79-17334**
AVEADCOM-TR-79-18			DOE/NASA/2593-79/1 p0089 N7	
AVRADCOM-TR-79-19			DOE/NASA/2593-79/6 p0139 N7	
AVRADCOM-TR-79-20	p0116	N79-32552**	DOE/NASA/2674-78/1 p0133 N7	79-11478**
AVRADCOM-TR-79-26	p0116	N79-33476*#	DOE/NASA/2674-78/2 p0136 N7	79-17335*#
AVRADCOM-TB-79-47			DOE/NASA/2674-79/1 p0068 N7	79-20200**
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			DOE/NASA/2674-79/4 p0139 N7	
BCS-40159-1			DOE/WASA/2674-79/5 p0138 N7	19-24446**
BCS-40180-2-BEV			DOE/NASA/2674-79/6 p0142 N7	
BCS-40262-1			DOE/NASA/3082-78/1 p0130 N7	
BCS-40262-2	PU167	m/9-33884*#	DOE/NASA/7653-79/1 p0153 N7	
			DOE/NASA/9773-78/1 p0150 N7	79-10525*#
C-081	p0142	N79-28727**	DOE/NASA/11272-79/1 p0139 N7	
C-9180				
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			DOE/NASA/20485-79/1 p0138 N7	79-24443*#
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CONS/4396-3			D6-48097 p0091 N7	
COMS/5081-1	p0151	N79-11473**	D6-48611 p0009 N7	79-23940**
The state of the s			D6146 p0087 N7	
CREARE-TN-289	p0111	#79-27#78##		
CREAR-IN-209	Point	#13-21410-4	B-001	70-2000044
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C76-1555/501			E-003 p0131 N7	
C79-386/501	p0180	N79-27975*#	E-004 p0018 N7	79-23964*#
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			E-006 p0003 N7	
DDA-EDR-9528	p0033	N79-21073**	E-010	79-23965**
DDA-EDR-9719	p0189	N79-31087*#	E-011 p0173 N7	79-24770**
DDA-EDR-9790			E-012 p0046 N7	
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DDA-RN-79-4	p0107	N79-28456*#	E-013 p0018 N7	79-23966*#
			E-014 p0104 N7	
non Januarana		W70 4355444		
DOC-78SDS4252			E-015 p0109 N7	
DOC-79SDS4218	p0 153	N79-26506**	E-016 p0138 N7	79-24444*
			E-018 p0137 N7	79-22624*6
DOR/WASA/0004-79/1	n0189	N79-32129##	E-023 p0140 N7	
DOE/WASA/2008-78/4			E-025 p0094 k7	
DOE/NASA/0012-78/1-VOL-1			E-026 p0022 N7	
DOB/NASA/0012-78/1-VOL-2	p0152	N79-13497**	E-027 p0004 N7	79-23912**
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DOE/NASA/0019-78/1			E-030 p0174 N7	
DOE/HASA/0028-79/1	p0189	179-31087*#	E-031 p0174 N7	79-25841*#
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DOE/WASA/0038-79/1			E-035 p0142 N7	
DOE/ NASA/0040-78/1			E-036 p0138 N7	
DOE/MASA/0042-79/1-VOI-1			E-038 p0165 N7	
DOE/NASA/0042-79/2-VOL-2			E-039	
DOD/ ##3#/ 0042-79/2-TOL-2	PO 100	#79-33662+#		
DOE/WASA/0042-79/3-VOL-1			E-040 p0043 N7	
DOE/NASA/0042-79/4-VOL-2	P0167	¥79-33884*#	E-042 p0053 N7	
DOE/NASA/0067-79/1	p0153	N79-29604*#	E-043 p0004 N7	79-27093**
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DOE/NASA/0207-79/1			E-046	
			2 040 p00/5 N/	70 23130**
"OE/NASA/0207-79/3			E-048 p0127 N7	
DOE/NASA/0615-79/1	n0153	¥79-19454*#	E-049 p0044 N7	
	Po		E-050 p0022 N7	79-25015**
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DOE/HASA/1002-78/1	p0133			
DOE/NASA/1002-78/1	p0133 p0138	¥79-24445*#	E_0E0	
DOE/ NASA/1002-78/1 DOE/ NASA/1002-78/2 DOE/ NASA/1002-79/3	p0133 p0138 p0138	¥79-24445*# ¥79-24442*#	E-052 p0115 N7	79-24350*#
DOE/HASA/1002-78/1 DOE/HASA/1002-78/2 DOE/HASA/1002-79/3 DOE/HASA/1002-79/4	p0133 p0138 p0138 p0141	879-24445*8 879-24442*8 879-26505*8	E-053 p0141 N7	79-24350*# 79-26505*#
DOE/NASA/1002-78/1 DOE/NASA/1002-78/2 DOE/NASA/1002-79/3 DOE/NASA/1002-79/4 DOE/NASA/1004-79/1	p0133 p0138 p0138 p0141 p0136	N79-24445** N79-24442** N79-26505** N79-20494**	E-053	79-24350** 79-26505** 79-27242**
DOE/NASA/1002-78/1 DOE/NASA/1002-78/2 DOE/NASA/1002-79/3 DOE/NASA/1002-79/4 DOE/NASA/1004-79/1	p0133 p0138 p0138 p0141 p0136	N79-24445** N79-24442** N79-26505** N79-20494**	E-053	79-24350** 79-26505** 79-27242**
DOE/NASA/1002-78/1 DOE/NASA/1002-78/2 DOE/NASA/1002-79/3 DOE/NASA/1002-79/4 DOE/NASA/1004-79/1 DOE/NASA/1004-79/16	p0133 p0138 p0138 p0141 p0136 p0140	N79-24445*6 N79-24442*6 N79-26505*6 N79-20494*6 N79-26502*6	E-053	79-24350*# 79-26505*# 79-27242*# 79-30355*#
DOE/HASA/1002-78/1 DOE/HASA/1002-78/2 DOE/HASA/1002-79/3 DOE/HASA/1002-79/4 DOE/HASA/1004-79/1 DOE/HASA/1004-79/16 DOE/HASA/1011-78/28	p0133 p0138 p0138 p0141 p0136 p0140 p0017	第79-24445 * 6 第79-24442 * 6 第79-26505 * 6 第79-20494 * 6 第79-26502 * 8 第79-17859 * 6	E-053 P0141 E7 E-057 P0059 N7 E-058 P0075 N7 E-059 P0043 N7	79-24350 • # 79-26505 • # 79-27242 • # 79-30355 • # 79-25129 • #
DOE/HASA/1002-78/1 DOE/HASA/1002-78/2 DOE/HASA/1002-79/3 DOE/HASA/1002-79/4 DOE/HASA/1004-79/1 DOE/HASA/1004-79/16 DOE/HASA/1011-78/28 DOE/HASA/1011-78/29	P0138 P0138 P0138 P0141 P0136 P0140 P0017 P0014	179-24445*8 179-24442*8 179-26505*8 179-20494*8 179-26502*8 179-13049*8	E-053	79-24350*# 79-26505*# 79-27242*# 79-30355*# 79-25129*# 79-25131*#
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DOE/HASA/1002-78/1 DOE/HASA/1002-78/2 DOE/HASA/1002-79/3 DOE/HASA/1002-79/4 DOE/HASA/1004-79/1 DOE/HASA/1004-79/16 DOE/HASA/1011-78/28 DOE/HASA/1011-78/29	p0133 p0138 p0138 p0141 p0136 p0140 p0017 p0014 p0136	N79-24445*6 N79-24442*6 N79-26505*6 N79-26502*6 N79-26502*6 N79-17859*6 N79-13049*6 N79-17336*8	E-053	79-24350*# 79-26505*# 79-27242*# 79-30355*# 79-25129*# 79-25131*# 79-27140*#
DOE/HASA/1002-78/1 DOE/HASA/1002-78/2 DOE/HASA/1002-79/3 DOE/HASA/1002-79/4 DOE/HASA/1004-79/1 DOE/HASA/1004-79/16 DOE/HASA/1011-78/28 DOE/HASA/1011-78/29 DOE/HASA/1022-78/42 DOE/HASA/1028-72/2	p0133 p0138 p0138 p0141 p0136 p0140 p0017 p0014 p0136 p0137	879-24445*8 879-24442*8 879-26505*8 879-26502*8 879-17859*8 879-13049*8 879-17336*8 879-21549*8	E-053 P0141 B7 E-057 P0059 B7 E-058 P0075 B7 E-059 P0043 B7 E-060 R0053 B7 E-062 P0022 B7 E-064 P0104 B7	79-24350*8 79-26505*8 79-27242*8 79-30355*8 79-25129*8 79-25131*8 79-27140*8
DOE/HASA/1002-78/1 DOE/HASA/1002-78/2 DOE/HASA/1002-79/3 DOE/HASA/1002-79/4 DOE/HASA/1004-79/1 DOE/HASA/1004-79/16 DOE/HASA/1011-78/28 DOE/HASA/1011-78/29 DOE/HASA/1022-78/42	p0133 p0138 p0138 p0141 p0136 p0140 p0017 p0014 p0136 p0137	879-24445*8 879-24442*8 879-26505*8 879-26502*8 879-17859*8 879-13049*8 879-17336*8 879-21549*8	E-053 P0141 N7 E-057 P0059 N7 E-058 P0075 N7 E-059 P0043 N7 E-060 R0053 N7 E-062 P0022 N7	79-24350*8 79-26505*8 79-27242*8 79-30355*8 79-25129*8 79-25131*8 79-27140*8

E-06C				E-9670	**********		
E-071				E-9673			
E-072				E-9673-1			
E-075				1-9681	***************************************		N79-15184*#
E-078		p0094	N79-27351**	E-9684		P0114	N79-14386**
E-082		p0168		E-9688	***********		
E-088		p0089	N79-28349**	E-9694			N79-10023*#
E-089		p0022	N79-27141*#	E-9697		p0082	N79-23216**
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E-092				E-9713		p0052	N79-10122**
E-093			879-27930**	E-9714		p0024	N79-31214**
E-094				E-9715			N79-13159**
E-095			N79-27279**	E-9720			
E-096			N79-29143*#	E-9728			N79-22375**
				E-9729			
E-098				E-9730			
B-100							
E-106	•••••			E-9732			
E-107				E-9735			N79-21120**
E-110				E-9743	***************************************		
E-111			N79-29224**	E-9745	***************************************		N79-12203**
E-112	*****		N79-29938*#	E-9749	**********		
E-115		p0090	N79-31405*#	E-9754		p0181	N79-19367**
E-116		p0142	N79-28726*#	E-9756		p0003	N79-14996*#
E-118		p0064	N79-30296**	E-9762		p0015	N79-14099*#
E-120				E-9763			N79-17659**
E-123				E-9765			N79-17227**
E-125			N79-30356*#	E-9767			N79-18288**
E-130			N79-29329*#	E-9769			N79-11109*#
E-131				1-9770	***************************************		N79-21205**
				E-9774			
E-132				E-9775			N79-17859*#
E-134			N79-31349*#				N79-17659+
E-141				E-9777	*****		
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E-143	***************************************		N79-30187*#	E-9779			N79-11479*#
E-146				E-9780			N79-11955*#
E-148	***************************************			E-9782	***************************************		N79-12016*#
E-149				E-9783			N79-11478**
E-151				E-9785			N79-11000*#
E-152		p0084	N79-31391*#	E-9786			N79-30191*#
E-153		p0125	N79-29530*#	E-9787		p0073	N79-11179*#
E-155		p0048	N79-31265*#	E-9788	• • • • • • • • • • • • • • • • • • • •	p0133	N79-11477*#
E- 16 1				E-9789			N79-12204*#
E-165				E-9790			
E-166				E-9792			
E-168			N79-33252*#	E-9795		p0137	N79-22626**
E-169			N79-33253**	E-9796			N79-12361*#
E-170				1-9799			N79-17335*#
			N79-30515*#				
E-171			N79-33306*#	E-9800	***************************************		N79-15961*#
E-174				E-9801			n79-23688**
E-175			N79-33254*#	E-9802	***************************************		¥79-15051*#
E-176			N79-33185*#	E-9803	***************************************		
E-180			N79-33379*#	E-9804			N79-15199*#
E- 18 1			H79-31343*#	F-9805			N79-15150**
E-183			N79-30188**	E-9806			N79-22519**
E-188	***************************************		N79-31372*#	E-9807			N79-17334*#
E-191			N79-33255*●	E-9808		p0109	N79-17195*#
E-236		p0116	N79-33477*#	E-9809			
E-100		p0053	#79-22193*#	E-9811		p0136	N79-17336*#
E-834		p0163	N79-25753**	£ 9813		p0111	N79-21329*#
E-895			N79-28176*#	I-9814			N79-21204**
E-895			N79-23967*#	E-9815			N79-22518*#
E-898			N79-28177**	E-9816	***************************************		N79-18479*#
E-899				E-9817			
E-902		p0002	N79-10022**	E-9818			
B-912			N79-10424 *#	E-9819			
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E-917				E-9822			
	i-1			E-9823			
E-918				E-9824			
E-918				E-9824			
E-921				E-9827	***************************************		
E-923				E-9828	***************************************		
	5-1			E-9829	***************************************		
E-934				E-9830	***************************************	p0069	m/9-22246##
E-941				E-9831			
E-941				E-9832			
E-946				1-9833	***************************************		
E-949				E-5-34	***********		
E-951				F-9835			
E-952				E-9836			
B-957		p0097	N79-14309*#	E-9838			
E-958				E-96J9			
E-960				E-9840	*********		
E-962				E-9841			
E-963				F-9842			
E-964				E-9844			
E-965				E-9845	***************************************		
B-965				F-9846		p0022	N79-25023##
E-965					1		
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E-9847		p0102	N79-12362**	F-9956	DODEC	N70-3434544
E-9848		p0188	N79-16721*#	E-9957		
E-9853		p0015	879-15047**	E-9958	20018	N79-21950+
E-9854				E-9960	50003	N79-20069**
E-9857		p0126	879-15325+#	F-9961	p0003	N79-20009-1
E-9860	***************************************	p0002	N79-12020**	E-9962	p0169	N79-23735**
E-9861	***************************************	p0172	N79-16644*#	E-9963	p0103	N79-2073344
E-9862		p0015	N79-15048**	E-9965	00084	N79-30381**
E-9863		p0015	N79-15050**	E-9966	00103	N79-20346**
E-9865		p0003	N79-14998**	E-9968	p0103	
E-9866				E-9969	PO 105	N79-22363+#
E-9867		p0127	N79-20391**	E-9970	p0136	N79-29407+4
E-9868				E-9971	P0130	N79-20490+
E-9870	***************************************	p0053	N79-23132**	E-9972	00150	N79-2/309+4
E-9872	***************************************	p0157	N79-15448**	1-9973	p0136	N79-33041+#
E-9873		p0015	N79-15049**	F-9974	P0073	N79-22426**
E-9874				E-9976	P0104	N70-22420+8
E-9375		B000g	N79-15013*#	E-9977	P0097	N79-23340**
E-9876		p0083	N79-29327**	E-9979	P0113	N79-20354**
E-9877		p006	N79-16075**	Σ-9981	p0127	N79-20398**
E-9878		p0062	N79-1692144	E-9982	P0131	N79-22590**
E-9879		p0081	N79-15185**	E-9983	P0019	N79-23909**
E-9880		p0105	N79-30516**	E-9984	P0191	N79-22897**
E-9881	***************************************	p0061	N79-16076*4	E-9985	P0012	N79-23963**
E-9882	***************************************	p0126	N79-16300**	E-9986	P0137	N79-226 (3*#
E-9883		p0138	N79-24445**	E-9987	p0139	N79-254_3*#
E-9884		00061	N79-16918**	E-9988	P0139	N79-25499**
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E-9886	***************************************	p0022	N79-2502244		P0008	M79-331'1##
E-9887		p0126	N79-1532644		P0116	N79-3 552*#
E-9888	***************************************	p0016	N79-15959**	E-9993E-9994	50008	B79-31499##
E-9889		p0017	N79-15969**	E-9995	p0052	N79-22190**
E-9890		p0017	N79-16849**	E-9996	P0053	N79-22192*#
E-9891	***************************************	p0016	N79-15960**		P0138	N79-24442*#
E-9892	***************************************	00016	N79-15958**	E-9997 E-9999	P0144	N79-33572**
E-9893	***************************************	00089	N79-20265**	E-10000	P0004	N79-26019**
E-9894		p0062	N79-2018644	E-10000	b0033	N/9-2325/**
E-9895		p0127	N79-20390**	EPRI-RP1082-1-VOL-1	-0151	W70 47:0044
E-9898		00089	N79-1513684	EPEI-BP1082-1-VOL-2	P0151	N79-13496*#
E-9859		p0173	N79-16645*#	EFET-BF1002-1-40L-2	P0152	N /9-1349 /##
E-9901		p0061	N79-16077**	ERIM-126100-3-F	-0121	W70 1757844
E-9902		p0173	N79-16646*#	EAST 120100 3 1	Poisi	1179-12524**
E-9903		p0038	N79-28186*#	EXXON/GRUS.1KWD.78	-0004	W20 2026744
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E-9905		p0134	N79-15410**	E79-10006	-0171	M70-1050844
E-9907	***************************************	p0136	N79-20494*#	275 10000	Po 13 1	N/9-12524*#
E-9908		p0126	N79-17263**	FAA-NA-78-156	n.0046	N70 1505044
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E-99 13		p0017	879-20114*#	FCB-0945	P0151	N79-12553*#
E-9914	***************************************	p0173	N79-20829**	FCR-1017	P0154	N70-31/84*#
E-9915		E0074	N79-20217**		Poiss	W / 3 - 3320 1+#
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E-9922	***********	p0094	N79-20300*#			
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E-9930		p0069	N79-25191*#	HAC-REF-E1992-2	p0096	N79-33374**
E-9931		p0137	N79-20520**		1.000	23314-8
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E-9933		p0019	N79-24994*#		F = 122	
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E-9938		pu165	N79-20752*#			
E-9939		p0103	N79-20337 · •	IFSM-79-95	p0067	N79-30204**
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E-9943		P0038	N79-33210 ●#			
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E-9946		p0023	N79-27142*#			
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E-9949		P0115	#79-31604*#	LMSC-D673466-VCL-2	p0112	N79-21335*#
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	NASA-CR-3197 p0072 N79-33288+#
LYC-77-65	NASA-CR-134526 p0080 N79-33305+#
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FASA-CASE-LEW-12252-1 p0102 N79-13288*	
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and the second of the second o	N'SA-CE-159449 p0033 N79-20116*#
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NASA-CP-2011	NASA-CR-159-54
NASA-CE-3078	NASA-CE-159455
NASA-CP-2096	NASA-CE-159456
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NASA-CR-159480	p0091	N79-20267*# I	NASA-CR-159624		20030	870-20100+4
NASA-CR-159481				-1	P0033	M70-23103**
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NASA-CR-159530	c0153	N79-20497 **	NASA-TH-78970		pC013	N79-1108300
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NASA-CR-159540	P0034	879-23004-1 870-3530544	NASA-TH-78993	•••••	p0017	N79-17859*#
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	PO 100	n/9-25312*#	NASA-TH-79029		p0073	N79-12201*#
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NASA-CR-159602			NASA-TH-79034		p0135	N79-16357 • #
NASA-CH-159603	D0034	79-25017**	NASA-IM-79035		p0068	179-16930 · #
NASA-CB-159604	F. 163	N/9-3'087**	NASA-TH-79036		p0062	N79-12154+#
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SSS-R-78-3739	-0100	N70-27200+4	US-PATENT-CLASS-55-155		
SSS-E-79-3904	p0100	N79-2/398*#	US-PATENT-CLASS-55-241		
333-1-79-3304	P0100	M/9-2/39/**	US-PATENT-CLASS-55-242 US-PATENT-CLASS-55-360		
SU-HBT-27	20106	N7G-2202044			
SU-HMI-28			US-PATENT-CLASS-55-407 US-PATENT-CLASS-60.39.08		
	Port.	873-22423**			
TELEDYNE-CAE-1600	p0039	N79-29189**	US-PATENT-CLASS-60-39.14		
	£-033		US-PATENT-CLASS-60-39.31		
TR-79-1	p0072	879-32303**	US-PATENT-CLASS-60-39.66		
TR-251	p0091	N79-20266**	US-PATENT-CLASS-60-226A		
			US-PATENT-CLASS-60-226A		
TRS-101	p0153	N75-20497**	US-PATENT-CLASS-60-226B		
			US-PATENT-CLASS-60-267	p0102	N79-13288*
TRW-ER-8019-1			US-PATENT-CLASS-60-267		
TRW-FR-8028	p0079	179-11180 · i	US-PATENT-CLASS-62-268	p0103	N79-20336*
			US-PATENT-CLASS-62-376	p0103	N79-20336*
TRW-30979-6003-BU-00	F0107	N79-22434*#	US-PATENT-CLASS-62-514R		
TEW-31781-6016-RU-00			US-PATENT-CLASS-73-115		
TRW-32100-6009-RU-00			US-PATENT-CLASS-136-89		
TRW-32937-6001-TU-00 TRW-33631-6006-RU-00			US-PATENT-CLASS-136-89CC		
TRW-33631-6006-RU-00	puluu	1/9-25312**	US-PATENT-CLASS-136-89SJ		
CCLA-ENG-7718	n0130	N79-1941444	US-PATENT-CLASS-136-89SJUS-PATENT-CLASS-136-202		
	10.00	373 12414.4	US-PATENT-CLASS-136-236		
UDR-TR-79-17	p0096	N79-17071+4	US-PATENT-CLASS-137-15.1		
UDR-TE-79-18-VGL-1			US-PATENT-CLASS-137-15.1		
UDR-TR-79-19-VOL-2			US-PATENT-CLASS-148-2		
			US-PATENT-CLASS-148-6.3		
US-PATENT-APPL-SN-007083	P0073	N79-19145*#	US-PATENT-CLASS-148-12.4		
		N79-18455*#	US-PATENT-CLASS-148-12F	p3074	N79-22271*
		N79-24061*#	US-PATENI-CLASS-148-188		
		N79-23383**	US-PATENT-CLASS-156-17		
		N79-24154*#	US-PATENT-CLASS-165-146		
		N79-31345*# N79-32463*#	US-PATENT-CLASS-165-169		
		N79-21225*			
		N79-17192*	US-PATENT-CLASS-181-190		
		N79-21910*	US-PATENT-CLASS-181-222		
		N79-14095*	US-PATENT-CLASS-181-293		
		N79-14096*	US-PATENT-CLASS-195-103.58		
US-PATENT-AFPL-SN-559846		N79-13289*	US-PATENT-CLASS-195-127		
US-PATENT-APPL-SN-559847	10102	N79-13288*	US-PATENT-CLASS-204-1T		
US-PATENT-APPL-SN-573029	P0014	N79-14097*	OS-PATENT-CIASS-222-131	F0093	N79-21225*
		N79-14346*	DS-PATENT-CLASS-239-127.1		
		N79-14871*	US-PATENI-CLASS-239-127.1		
		N79-11403*	US-PATENT-CLASS-239-265.39		
		N79-14096*	US-PATENT-CLASS-244-53B		
		N79-14528*	US-PATEN'-CLASS-244-54		
		N79-10339 •	US-PATENT-CLASS-250-352	pu 103	N79-20336*
		N79-22235* N79-10057*	US-PATENT-CLASS-252-12.2 US-PATENT-CLASS-260-37N		
		N79-17313+	US-PATENT-CLASS-260-37N		
		N79-10418*	US-PATENT-CLASS-260-53		
		N79-28307*	US-PATENI-CLASS-277-62		
		N79-11468*	US-PATENT-CLASS-277-96.1		
		N79-18318*	US-PATENT-CLASS-301-82		
US-PATENT-AFFL-SN-803822	F0074	N79-22271*	DS-PATENT-CLASS-308-DIG.1		
US-PATENT-APPL-SN-803823	p0133	N79-11467*	US-PATENT-CLASS-308-DIG.8		
		N79-22475*	US-PATENT-CLASS-308-DIG.9		
		N79-20336*	US-PATENT-CLASS-308-5E	p0113	N79-10418*
		N79-14345*	US-PATENT-CLASS-308-9	p0113	N79-10418*
		N79-11472*	US-PATENT-CLASS-308-78		
		N79-142"6*	US-PATENT-CLASS-308-878		
	PU104	N79-21313*t	IS-PATENT-CLASS-308-121		N/9-10418*
	m (3/3/7 to )	#76-33334A			William Address of the Control of th
		N79-22271* N79-17916*	US-PATENT-CLASS-308-160		N79-10418*

US-PATENT-CLASS-308-168	p0062 N79-1791	6.0
US-PATENT-CLASS-308-171	p0062 N79-179	16.0
DF DAMENG CLASS 300 173	p0113 N79-104	
NO DIMENS OFFICE SAN AN		
US-PATENT-CLASS-313-22	p0103 N79-2033	
US-PATENT-CLASS-313-35	p0103 N79-2033	16+
US-PATENT-CLASS-315-3.5	p0102 N79-1033	
THE RESIDENCE OF SAME AS A SECOND		
US-PATENT-CLASS-323-15	p0052 N79-2017	19*
US-PATENT-CLASS-323-20	p0052 N79-2017	19*
US-PATENT-CLASS-330-43	p0102 N79-1033	
DE DARRES CLACE 357 45		
HC DAMENE OLLOG SET AC		
US-PATENT-CLASS-357-16	p0133 N79-1146	7.
US-PATENT-CLASS-357-30	p0133 N79-1146	7.
US-PATENI-CLASS-357-30	pC134 N79-1452	*8
DE DAMENE OFFICE SET OF	p0133 N79-1146	
DE DIFFRE CLICE 357 (7		
	p0133 N79-1146	
US-PATENI-CLASS-415-115	p0013 #79-1005	7*
US-PATENT-CLASS-415-116	p0013 N79-1005	7#
HO DAMPHE OF LOD BAC 474	p0114 N79-1831	
DC DAMENT CLACK DAE 200		
	p0014 N79-1409	
US-PATENT-CLASS-415-200	p0114 N79-1631	8.
US-PATENT-CLASS-415-201	p0014 N79-1409	6.
HC NAMERO CTACC NAC ACON	p0014 N79-1409	
	p0014 N79-1409	
US-PATENT-CLASS-416-162	p0014 N79-1409	5*
US-PATENT-CLASS-416-167	p0014 N79-1409	15.
DC DAMENS CLACK NOT 30	p0062 N79-1791	
US-PATENT-CLASS-427-75	p0133 N79-1146	8.8
US-PATENT-CLASS-427-75	p0133 N79-1147	2*
US-PATENT-CLASS-427-84	p0133 #79-1147	2.4
	p0133 N79-1147	
US-PATENT-CLASS-427-126	p0133 N79-1147	
US-PATENT-CLASS-427-261	p0133 N79-1147	2*
US-PATENT-CLASS-427-292	p0062 N79-1791	6.4
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TO DEPEND OF LOG HOT THE		
US-PATENI-CLASS-427-328	p0062 N79-1791	
US-PATENT-CLASS-427-343	p0133 N79-1147	2.0
US-PATENT-CLASS-427-355	p0062 N79-1791	6.4
TO DIMENE OFFICE PAR SECT	p0062 N79-1791	
HC DAMPER CLACK BOD DOG	grand many result	
US-PATENT-CLASS-427-376C	pn062 k79-1791	
US-PATENT-CLASS-427-398A	p0133 N79-1147	2*
US-PATENT-CLASS-427-399	p0133 N79-1147	2*
US-PATENT-CLASS-429-15	p0139 N79-2647	
The District of the same and		
	p0135 ¥79-1731	
US-PATENT-CLASS-429-101	p0135 N79-1731	3*
US-PATEN1-CLASS-429-101	-0120 870 3687	10.4
	DUISS B/3-204/	
US-PATENT-CIASS-429-253	p0139 N79-2647	
US-PATENT-CLASS-429-253	p0138 N79-2548	1*
US-PATENT-CLASS-526-7	p0138 N79-2548 p0138 N79-2548	1*
	p0138 N79-2548	1*
US-PATENT-CLASS-526-7	p0138 N79-2548 p0138 N79-2548 p0138 N79-2548	1* 1* 1*
US-PATENT-CLASS-526-7 US-PATENT-CLASS-526-9 US-FATENT-CLASS-528-126	p0138 N79-2548 p0138 N79-2548 p0138 N79-2548 p0083 N79-2830	1* 1* 1* 7*
US-PATENT-CLASS-526-7 US-PATENT-CLASS-526-9 US-PATENT-CLASS-528-126 US-PATENT-CLASS-528-127	p0138 N79-2548 p0138 N79-2548 p0138 N79-2548 p0083 N79-2830 p0083 N79-2830	1* 1* 1* 7*
US-PATENT-CLASS-526-7 US-PATENT-CLASS-526-9 US-PATENT-CLASS-528-126 US-PATENT-CLASS-528-127 US-PATENT-CLASS-528-127	p0138 %79-2548 p0138 %79-2548 p0138 %79-2548 p0083 %79-2830 p0083 %79-2830 p0083 %79-2830	1* 1* 7* 7*
US-PATENT-CLASS-526-7 US-PATENT-CLASS-526-9 US-PATENT-CLASS-528-126 US-PATENT-CLASS-528-127 US-PATENT-CLASS-528-128 US-PATENG-CLASS-528-221	p0138 N79-2548 p0138 N79-2548 p0138 N79-2548 p0083 N79-2830 p0083 N79-2830	1* 1* 7* 7*
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US-PATENT-CLASS-526-7 US-PATENT-CLASS-526-9 US-FATENT-CLASS-528-126 US-PATENT-CLASS-528-127 US-PATENT-CLASS-528-127 US-PATENT-CLASS-528-121 US-PATENT-CLASS-528-221 US-PATENT-CLASS-528-223 US-PATENT-CLASS-528-227 US-PATENT-CLASS-528-227 US-PATENT-CLASS-528-237 US-PATENT-CLASS-528-331 US-PATENT-CLASS-528-337 US-PATENT-CLASS-528-337	P0138 N79-2548 F0138 N79-2548 F0138 N79-2830 F0083 N79-2830	1* 1* 1* 7* 7* 7* 7* 7* 7* 7* 7* 7* 7* 7* 7* 7*
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